7

October
2003

DEVELOPING IMPROVED HEIFER REARING SYSTEMS

AgriSearch NI
Farmer Funded Research

AgriSearch NI
Farmer Funded Research

AgriSearch was formed in 1997 to provide a mechanism through which dairy, beef and sheep farmers could have a direct involvement in near market research. Funds contributed to AgriSearch are used to commission research into the improvement and development of sheep, beef and dairy farming and to disseminate and publish the results. Dairy projects are recommended to the AgriSearch Council by a Dairy Advisory Group comprised of five people, of which three are farmers. The AgriSearch Council is comprised of ten people of which six are farmers.

The Agricultural Research Institute of Northern Ireland,
Hillsborough, Co. Down, BT26 6DR

Research Team
Alistair Carson, Lynne Dawson and Fred Gordon

CO-FUNDERS
Department of Agriculture and Rural Development for Northern Ireland

OVERALL SUMMARY OF PROJECT

Two studies (A and B) were undertaken over three years to investigate the effect of heifer rearing system on subsequent dairy cow performance. In study A (years 1 and 2), 221 heifers were sourced from twelve dairy producers located throughout Northern Ireland and the herd at the Agricultural Research Institute of Northern Ireland (ARINI). In year 1, heifers were reared at ARINI and returned to the farm of origin at 24 months old, where lactational performance was assessed. In year 2, detailed mammary gland and feet measurements of heifers were recorded at 18 months of age. Study B involved 100 heifers sourced and reared at ARINI. Detailed feed intake and hormone measurements were undertaken on these heifers. In both studies, heifers were reared on either silage- or straw-based diets, to calve at either 540 kg or 620 kg at 24 months of age. Heifers reared to calve at 620 kg produced 11% more milk in their first lactation than those calving at 540 kg and had longer calving intervals (32 days longer). In view of the greater weight losses and lower feed intake experienced by the 620 kg heifers in the first three months of lactation, the increased milk yield appears to have been achieved through greater mobilisation of body reserves, rather than increased food intake. In the second and third lactations, live weight at first calving had no effect on milk yield. **At current milk prices, the extra milk produced by the heavier heifers does not compensate for the extra rearing costs.** Rearing heifers to heavier weights increased the incidence of heel erosion which may be a reflection of the higher levels of concentrate offered during the rearing period and increased pressure on the claws due to the greater live weight of the heifers. Diet type offered during the rearing period had no effect on milk production, live weight change in early lactation or reproductive performance, although there were indications that straw-based diets had a beneficial effect on the incidence of feet problems.

INTRODUCTION

Feeding and management during the rearing period has a major effect on the performance, reproduction, health and welfare of dairy herd replacements. Research undertaken in the 1960's and early 1970's has been used as a basis for heifer rearing systems in the UK and Ireland. However, with the rapid increase in the genetic merit of dairy herd replacements there is an urgent need to undertake research to develop appropriate rearing systems for today's high genetic merit Holstein-Friesian heifer. In recent years there has been an impetus to increase live weight at first calving, in line with the higher mature weights of Holstein Friesian cows. However in order to develop appropriate rearing regimes, solid information on the effects of body size at first calving on subsequent performance of dairy herd replacements in Northern Ireland dairy systems is urgently required. Consequently, the first objective of this programme was to investigate the effect of weight at first calving of Holstein Friesian dairy herd replacements on subsequent milk output, reproductive performance and health.

Diet type offered during the rearing period may also affect heifer performance during the first lactation. In beef cattle, silage-based diets have been shown to increase fat deposition in the body compared to that obtained with cattle offered dried forages and concentrates. Information is also required on the effect of diet type on udder development, particularly in relation to fat deposition in growing dairy heifers. Therefore the second objective of the current study was to assess the effects of forage type offered during the rearing period on subsequent lactation performance.

PROCEDURE

Two studies were undertaken over six years

STUDY A (autumn 1996 and 1997 born heifers)

- This study involved 221 (113 autumn 1996 born and 108 autumn 1997 born) high genetic merit heifers sourced from twelve milk producers located throughout Northern Ireland, plus the herd at the Agricultural Research Institute of Northern Ireland.
- The autumn 1996 born heifers were reared at Hillsborough and returned to their farm of origin one month prior to calving where lactational performance was assessed on each of the farms.
- Detailed mammary gland, carcass and feet measurements were undertaken on the autumn 1997 born heifers at 18 months of age.

Treatment	Weight at calving (kg)	Diet type			
		Winter		Summer	
		Year 1	Year 2	Year 1	Year 2
1	540	Silage	Silage	Grass	Grass
2	620	Silage	Silage	Grass	Grass
3	620	Straw	Straw	Grass	Grass
4	620	Straw	Straw	Straw	Grass

Treatments

- Treatment 1 involved rearing heifers to moderate live weight 540 kg (80% of mature weight)
- Treatment 2 investigated the effects of increasing liveweight to 620 kg (90% of mature weight)
- Treatment 3 investigated the effects of changing to a straw-based diet during the winter period, whilst calving at 620 kg
- Treatment 4 investigated the effects of housing heifers during the first summer with animals first going out to grass as in-calf heifers and calving at 620 kg

STUDY B

- To investigate the mechanisms responsible for the effects of heifer rearing on subsequent performance, an additional 100 high genetic merit Holstein Friesian animals were reared at ARINI under four rearing regimes detailed below
- Detailed milk production, feed intake and hormonal recordings were taken at ARINI during the first lactation

Treatments

Treatment	Weight at calving (kg)	Diet type			
		Winter		Summer	
		Year 1	Year 2	Year 1	Year 2
1	540	Silage	Silage	Grass	Grass
2	540	Straw	Straw	Straw	Grass
3	620	Silage	Silage	Grass	Grass
4	620	Straw	Straw	Straw	Grass

- Heifers in both studies were mated at 14 months of age and calved at 24 months of age

REVIEW OF FINDINGS

Which calving weight?

Milk production

- Animals reared to calve at 620 kg produced 800 litres more milk in their first lactation, compared with those reared to calve at 540 kg (Table 1).
- Fat plus protein yield in the first lactation was increased by 33 kg in the heavier heifers relative to those calving at 540 kg.
- Weight at first calving had no effect on milk production, when expressed in terms of milk value, during the second and third lactation (Figure 1) or on total milk yield over the first, second and third lactation (Table 1).

Table 1. Effect of calving live weight on milk production

	Calving live weight	
	540 kg	620 kg
First lactation		
Milk yield (kg)	7222	8020
Fat (%)	3.81	3.70
Protein (%)	3.27	3.13
Fat plus protein yield (kg)	511	544
Milk value (£/heifer)†	1296	1387
First, second and third lactation		
Total milk yield (kg)	25570	27377
Total milk value (£/heifer)	4663	4752

† base price 18p/litre, base fat % 4.00, base protein % 3.18

Live weight change and reproductive performance

- Heifers reared to calve at 620 kg lost 66 kg more live weight in the first 3 months post-calving than those reared to calve at 540 kg (Table 2).
- By 305 days of lactation, heifers reared to calve at 540 kg had gained weight while those reared to the heavier weights were 58 kg lighter than their pre-calving live weight.
- Heifers reared to calve at 620 kg had a longer interval to first service and longer calving interval than those reared to calve at 540 kg. The lighter heifers continued to have shorter calving intervals in the second and third lactations.

Figure 1. Milk value (£/heifer) for 540 and 620 kg heifers during the first, second and third lactations

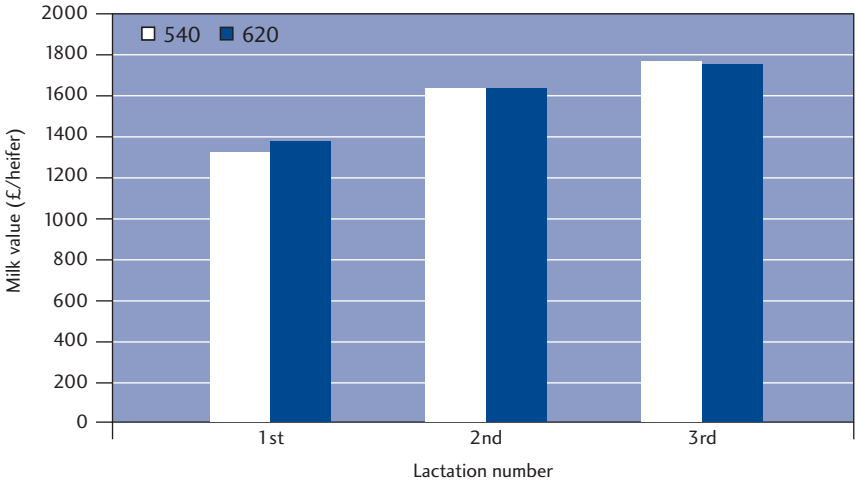

Table 2. Effect of calving live weight on live weight change and reproductive performance

	Calving live weight	
	540 kg	620 kg
Live weight change during 1st lactation (kg)		
Pre-calving to 3 months post-calving	-44	-110
Pre-calving to 305 days of lactation	21	-58
1st lactation reproductive parameters		
Calving to 1st service interval (days)	86	109
Calving interval (days)	394	426

Taking into account the increased milk production, poorer fertility and increased rearing costs associated with increasing calving live weight, over the first three lactations, animals calving at 540 kg produced an overall gross margin of £130 per heifer greater than those calving at 620 kg (Table 3).

Table 3. Performance of heifers reared to calve at 620 kg relative to those reared to calve at 540 kg (£) over three lactations

	Difference in margin between 620 kg vs 540 kg calving live weight heifers
Rearing cost (£)	- £140.00
Value of milk over three lactations†	+ £88.00
Fertility cost‡	- £77.50
Overall	**- £129.50**

† base price 18p/litre, base fat % 4.00, base protein % 3.18
‡ each day deviation from 365 days costed at £2.50/day

UDDER DEVELOPMENT, DRY MATTER INTAKE AND BLOOD HORMONE CONCENTRATIONS

- The amount of milk secretory tissue was similar in animals reared to 540 or 620 kg (Table 4).
- Dry matter intakes in early lactation were 4% higher (+0.6 kg/day) in heifers reared to calve at 540 kg compared with those reared to calve at 620 kg.
- Leptin, a hormone controlling food intake, was 14% higher for the heavier heifers which may partly explain the reduced food intake in these heifers.

Table 4. Effect of calving live weight on udder development, dry matter intake and blood hormone concentrations

	Calving live weight	
	540 kg	620 kg
Udder composition (18 months of age prior to turnout)		
Fat (g)	1190	1733
Milk secretory tissue (g)	761	938
Dry matter intake (kg/day)		
1st three months post-calving	17.2	16.6
Leptin concentration (mmol/l)		
1st three months post-calving	3.82	4.38

Feet development

- Heifers reared to calve at 620 kg had greater heel heights and longer outer claws than those reared to calve at 540 kg (Table 5).
- Weight exerted per area of feet was larger for the heavier heifers.
- Sole lesion scores were similar for heifers calving at both weights.
- Heifers reared to calve at 620 kg had higher heel erosion scores in the hind claws than those reared to calve at 540 kg.

Table 5. Effect of calving live weight on claw development

	Calving live weight	
	540 kg	620 kg
Height of heel (mm)	27	34
Claw length (mm)	112	120
Pressure (weight/foot area kg/mm^2)	0.037	0.040
Sole lesions score	1.9	1.5
Heel erosion scores†	3.5	8.0

† Higher scores indicate greater incidence of heel erosion

Which diet?

- Heifers reared on silage- and straw-based diets had similar levels of milk production in first, second and third lactation and similar total milk yield over the first, second and third lactation (Table 6).
- Live weight change during the first lactation was similar for heifers reared on both diets (Table 7).
- Similar intervals to first service and calving intervals for the first lactation were achieved for heifers on silage- and straw-based diets (Table 7).

Table 6. Effect of diet type during the rearing period on milk production

	Diet type	
	Silage	Straw
First lactation		
Milk yield (kg)	8020	7956
Fat (%)	3.70	3.70
Protein (%)	3.13	3.17
Fat plus protein yield (kg)	544	544
First, second and third lactation		
Total milk yield (kg)	27377	25767

Table 7. Effect of diet type on live weight change, reproductive performance and mammary development

	Diet type	
	Silage	Straw
Live weight change during 1st lactation (kg)		
Pre-calving to 3 months post-calving	-110	-122
Pre-calving to 305 days of lactation	-58	-73
1st lactation reproductive parameters		
Calving to 1st service (days)	109	120
Calving interval (days)	426	435

- Heifers reared on straw-based diets had a lower proportion of fat and a greater proportion of milk secretory tissue in the udder compared with heifers reared on silage-based diets (Table 8) when assessed at 18-months of age.
- Improvements in udder development in 18-month old heifers reared on straw-based diets during the winter were not correlated with improved milk production. Compensatory udder development may have occurred in the animals reared on the silage-based diets during the second summer at grass.
- Dry matter intakes after calving were similar in heifers reared on silage- or straw-based diets.
- Leptin concentrations were marginally higher in heifers reared on silage-based diets compared with those reared on straw-based diets.

Table 8. Effect of diet type during the winter rearing period on udder development at 18 months of age and dry matter intake and blood hormone concentrations after calving

	Diet type	
	Silage	Straw
Udder composition (18 months of age prior to turnout)		
Fat (g)	1733	1210
Milk secretory tissue (g)	938	1244
Dry matter intake (kg/day)		
1st three months post-calving	17.0	16.7
Leptin concentration (mmol/l)		
1st three months post-calving	4.47	3.73

Feet development

- Diet type had no significant effect on heel height or outer claw length (Table 9).
- Weight exerted per area of feet was similar for heifers reared on silage- or straw-based diets.
- Sole lesion scores were similar for heifers reared on silage- or straw-based diets.
- There were indications that heifers reared on silage-based diets had higher heel erosion scores in the hind claws than those reared on straw-based diets.

Table 9. Effect of diet type on claw development

	Diet type	
	Silage	Straw
Height of heel (mm)	34	37
Claw length (mm)	120	121
Pressure (weight/foot area kg/mm^2)	0.040	0.041
Sole lesions score	1.5	1.1
Heel erosion scores	8.0	5.7

† Higher scores indicate greater incidence of heel erosion

SUMMARY AND IMPLICATIONS FOR THE INDUSTRY

EFFECT OF WEIGHT AT CALVING

- Heifers reared to calve at 540 and 620 kg had similar amounts of milk secretory tissue in the udder.
- Heifers reared to calve at 620 kg produced 11% more milk in their first lactation than those reared to calve at 540 kg.
- The lower dry matter intakes and greater liveweight losses of the heavier heifers in the first three months post-calving indicate that the higher first lactation milk yield of heifers reared to 620 kg is due to increased mobilisation of body reserves.
- An increased interval to first service in heifers reared to calve at 620 kg relative to those reared to calve at 540 kg is likely to be related to the greater weight loss observed in the heavier heifers in early lactation.
- Milk yield in second and third lactations was not affected by live weight at first calving.
- Increasing live weight at first calving increased the incidence of heel erosion and increased pressure on the feet per unit area, increasing the risk of lameness.
- Overall, increasing body size at first calving from 540 to 620 kg increased first lactation milk yield but this was negated by longer calving intervals and over a three year period, milk production was similar in dairy replacements reared to calve at 540 and 620 kg.
- The performance, in terms of milk production, of heifers reared to heavier weights did not cover the increased rearing costs (£140/heifer in this study) and coupled with their poorer fertility indicates that rearing heifers to heavier weights cannot be justified. After three lactations 540 kg heifers produced an overall gross margin of £130/head greater than that of 620 kg heifers.

EFFECT OF DIET TYPE

- Silage- verus straw-based diets had no effect on
  - Milk production
  - Live weight change in early lactation
  - Reproductive performance
- Prior to turnout to grass, heifers reared on silage-based diets had a greater percentage of fat in the udder compared with those reared on straw-based diets. Compensatory udder development may have occurred in the heifers reared on silage-based diets so that, by calving any differences in the udder composition had disappeared resulting in similar levels of milk production.
- Straw-based diets reduced the incidence of heel erosion relative to silage-based diets possibly due to the increased dry matter content of the manure and hence drier conditions underfoot for heifers offered straw-based diets.
- Diet type offered during the winter feeding period had no effect on heifer performance in terms of milk production or reproductive performance although there were indications that straw-based diets had a beneficial effect on the incidence of feet problems.

This research programme indicates that the target body size for high genetic merit Holstein-Friesian heifers at first calving should be 540 to 560 kg, at a body condition score of 2.75 to 3.0. As this research programme develops further, information will be available on overall lifetime performance of the animals involved in the study.

THE PROJECT TEAM

We are grateful for the contribution made by the dairy farmers who participated in this programme by providing valuable data and assistance throughout: Mr S.M. McCollum, Coleraine, Messrs W. & A. McConnell, Armagh, Messrs S. & K. Montgomery, Londonderry, Mr E. Black, Londonderry, Messrs W. & A. McCollum, Coleraine, Mr P. Drayne, Lisburn, Mr J. Davidson, Ballywalter, Mr D. Johnston, Magherafelt, Mr J.G. Irwin, Eglish, Messrs D. & K. Telford, Fintona, Dunleath Estates Ltd., Ballywalter.

For further information or to request a copy of the full scientific report detailing the experimental tests and statistical analysis contact:

The Secretary
AgriSearch
97 Moy Road
Dungannon
BT71 7DX
Northern Ireland

T: 028 8778 9770
F: 028 8778 8200
E: info@agrisearch.org
W: www.agrisearch.org

AgriSearch NI
Farmer Funded Research