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Effect of heifer live weight on calving pattern and milk production

LR McNaughton* and T Lopdell
Livestock Improvement Corporation, Private Bag 3016, Hamilton 3240, New Zealand
**Corresponding author. Email: lmcnaughton@lic.co.nz*

Abstract

Many heifers on New Zealand dairy farms fail to reach their target live weight. This failure leads to lost milk production and poorer reproductive performance. This study investigated effects of breed and region on heifer live weight and also effects of pre-calving heifer live weight (18–21 months) on milk production. Less Friesian heifers reached their target live weight than Jerseys, or Crossbreds (85.3 versus 89.3 versus 88.1%; P <0.001). Heifers born in Otago (91.9%) and Taranaki (91.8%) were the closest to achieving their target live weight, whilst those born on the West Coast (85.6%) and Northland (86.0%) had the greatest number of heifers not reaching their target. Heifers that had only one calving recorded on the database were a significantly lower percentage of target live weight than those heifers that had two calvings recorded (83.5% versus 87.1%; P <0.001). In heifers with a live weight record between 18 and 21 months of age, every 1% increase in the percentage of target live weight attained was associated with an increase in milk volume of 23 ± 0.6 litres in the first lactation and 24 ± 0.9 litres in the second lactation. Further work is required on the economics of feeding heifers to achieve their target live weight.

Keywords: target live weight; dairy heifers; milk production; reproduction

Introduction

Research suggests that the majority of heifers on New Zealand dairy farms fail to reach their recommended target live weight (McNaughton & Lopdell. 2012). Failure to reach target live weights results in lost milksolids production (MacDonald et al. 2005) and poorer reproductive performance (Hayes et al. 1999). Many heifers are grazed off the dairy platform from weaning to 9–10 months of age, at a run-off block, or with a grazier. There is currently no information on variation in achievement of heifer target live weight on a regional or breed basis. The recording of heifer live weights on the Livestock Improvement Corporation database has increased significantly in recent years (McNaughton & Lopdell 2012), providing data to investigate regional and breed variation.

The first aim of this paper was to investigate regional and breed differences in achievement of target live weight by heifers. The second object was to establish whether there is a relationship between live weight and first calving pattern, first lactation milk production and likelihood of re-calving.

Materials and methods

Live weight records, live weight breeding and production values, birth dates, calving dates and milk production records for dairy animals that were born between 2007 and 2012, and were less than 730 days of age on the day of the live weight recording were extracted from the Livestock Improvement Corporation database in October 2012. First calving dates were compared to live weight records and any records where a live weight was recorded after calving was removed from the data set. Records with unusually light or heavy weights for their ages were removed as follows:

- All over 700 kg
- Older than 50 days but less than 30 kg
- Older than 150 days but less than 60 kg
- Older than 250 days but less than 90 kg
- Older than 350 days but less than 120 kg
- Older than 450 days but less than 180 kg
- Older than 500 days but less than 200 kg
- Younger than 600 days but more than 550 kg
- Younger than 500 days but more than 500 kg
- Younger than 450 days but more than 420 kg
- Younger than 400 days but more than 380 kg
- Younger than 350 days but more than 350 kg
- Younger than 250 days but more than 300 kg
- Younger than 200 days but more than 250 kg
- Younger than 150 days but more than 200 kg
- Younger than 50 days but more than 120 kg
- Younger than 20 days but more than 80 kg

All records with live weights equal to 400 kg, 500 kg or 600 kg were removed, as anomalously high numbers of records existed for these weights, due possibly to weights being rounded before recording. This left a data set of 884,495 records.

Insemination records for the herd that the heifers were born in were extracted and used to determine the mating start date (MSD). This was based on the InCalf definition where the MSD is a day when four out of the next seven days have inseminations recorded (M Blackwell, Personal communicatioon). The MSD for the heifers was estimated from the herd mating start date in the year of the heifer's birth, plus one year. Heifer target live weights were calculated relative to their herd MSD, reflecting the need for all animals to be at a target live weight at the start of mating, regardless of their birth date, with a target of 60% of their mature live weight. This meant that a heifer's age at each weighing needed to be adjusted for their birth date. Target live weights were calculated as if all animals were 15 months of age at the planned start of mating. They were calculated using a modified version of the growth prediction equation of Bryant et al. (2004) that uses live weight breeding values to estimate a cow's mature live weight. Live weight production values were also used to determine targets. Live weight production values include heterosis, which is not included in live weight breeding values. At each weighing the percentage of target weight reached was determined by comparing the heifer's actual live weight to her target live weight. For animals with a live weight breeding value of zero each percentage of target live weight is equivalent to 5kg of live weight.

Three subsets of data were made to examine relationships between live weight during the rearing period and future milk production and fertility. A subset of heifers that would be expected to have a calving recorded on the database was created from heifers born between 2007 and 2010 where heifers had a live weight recorded between two months prior and one month post the herd start of mating. Two further subsets of heifers were created from this data set. These were heifers that were born from 2007 to 2009 with a live weight recorded between 15 and 17 months of age (n=23,692), or between 18 and 21 months of age (n=32,040).

Statistical analysis of regional and breed effects was conducted in R 2.15.1(R Core Development Team 2012), and of effects of live weight on fertility and milk production in JMP 10.0 (SAS 2012). To determine the factors affecting the percentage of target live weight attained, a linear mixed effects model was fitted. The fitted factors were birth year, breed, age at weighing, region and herd. Herd was fitted as a random effect.

To determine the factors affecting 305-day milk yield a linear mixed effects model was fitted to the subsets of heifers with weights between 15 and 17 months, and between 18 and 21 months. Factors fitted to the model were percentage of target live weight, birth year, breed, region and herd. Herd was fitted as a random effect.

Heifers with a live weight recorded around the planned start of mating were divided into four groups, based on their percentage of target live weight attained. A linear model was used to investigate the effect of percentage of the target live weight attained on the number of days from the planned start of mating to first calving.

Differences in mean percentage of the target live weight attained between heifers that calved or failed to calve, heifers that recorded a second calving or did not record a second calving, and heifers that lactated for <80 days, or ≥ 80 days, were compared with a t-test.

Results

Breed, region, age at weighing, birth year and herd all significantly affected the proportion of the target live weight attained (P <0.001) and were able to explain 35% of the variation in the proportion of target live weight attained. Herd explained more of the variation than any of the other factors. Least square means of percentage of target live weight attained were significantly different between breeds (P <0.001) and are presented in Figure 1, with targets determined by live weight breeding values and live weight production values.

Figure 1 Least square mean percentage of target live weight by breed where the target live weights were calculated by live weight breeding values, or live weight production values.

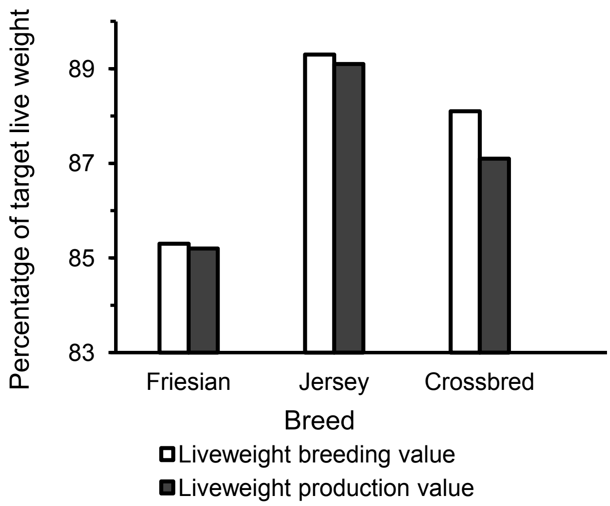
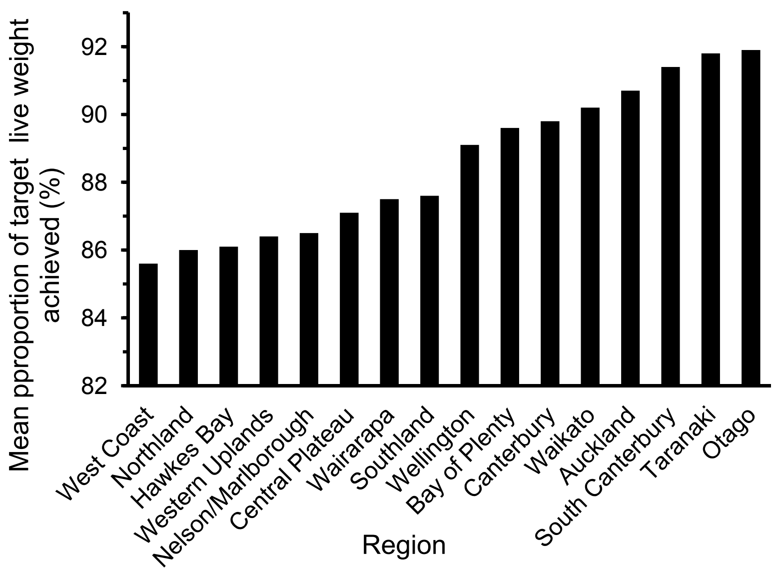


Figure 2 Least square means of percentage of target live weights attained by region of birth for data extracted from the Livestock Improvement Corporation database. The quoted regional names are those used in the annual New Zealand Dairy Statistics publication (DairyNZ 2012).



Heifers born in Otago (91.9%) and Taranaki (91.8%) were the closest to achieving target live weights, whilst those born on the West Coast (85.6%) and Northland (86.0%) were the furthest from their target by approximately 35 kg (Figure 2). Age at weighing had a significant positive relationship with percentage of target live weight attained. The percentage of target live weight attained increased by 0.01% for each one day increase in age at weighing.

Heifers with a live weight recorded between 15 and 17 months of age that failed to have a calving date recorded on the database attained a significantly lower percentage of their target live weight than heifers that did have a calving date recorded (84.2% versus 86.5%; P <0.001). Of the heifers that calved once, 17% failed to have a second calving recorded. Heifers that failed to record a second calving attained a lower percentage of target live weight at 15–17 months of age than those that were recorded as calving for a second time (83.5% versus. 87.1%; P <0.001).

There is a small but significant relationship between pre-mating live weight, from two months prior to one month after the planned start of mating date, and when an animal calves, relative to the herd's start of calving date (P <0.01). The relationship is curvilinear and strongest in the heifers that are the furthest from their target liveweight. Heifers that were between 40 and 65% (n = 854) of their target live weight calved 0.79 days earlier for every 1% closer to their target live weight. Heifers between 66% and 90% of their target live weight (n = 15,556) calved 0.28 days earlier for every 1% closer to their target live weight. Once heifers reached 90% of their target live weight (n = 17,532) the effect of additional live weight around mating was close to zero (0.05 days). There was a negative relationship between pre-calving live weight and calving date for heifers that were 115 to 140% of their target live weight (n = 890), each one percent increase in live weight attained resulted in a calving date that was 0.4 days later.

A positive relationship was identified between 305-day milk yield in first and second lactation and the percentage of their target live weight attained. A one percent increase in target live weight attained at 18–21 months resulted in an additional 23.2 ± 0.2 litres of milk in their first lactation. Further outputs from the model, including pre-calving live weight effects on milk production in Lactation 2 are summarised in Table 1. Heifers with a lactation length of <80 days in milk were a lower percentage of their target live weight at 15–17 months than heifers with a first lactation length of ≥80 days (84.8 versus 87.0%; P <0.001). The effect remained for heifers with a weight between 18 and 21 months of age. Those with a first lactation length of <80 days averaged 86.7% of their target live weight, compared to 91% of their target live weight for heifers with a first lactation of ≥80 days (P <0.001).

Discussion

This study has identified that herd, region, season, breed and age at weighing all affect the proportion of a target live weight attained by dairy heifers in New Zealand. The observed relationships suggest that heifers that are closer to their target have improved fertility and produce more milk. The most important factor determining the percent of target live weight attained was the herd factor, a proxy for management.

Regional and breed differences existed in how well heifers were achieving their target live weight. However, herd accounted for more of the variation, which suggests that regardless of location, or breed, good management enables heifers to achieve their target live weight. Improving young stock management should lead to increased milk production and fertility. Jersey and Crossbred heifers in this study were a greater percentage of their mature live weight than Friesian heifers, indicating that Jersey and Crossbred heifers are better able to reach their target live weight under the rearing conditions experienced on New Zealand dairy farms. The reasons for the differences between breeds found here are not known. One possibility is that in mixed-mobs the level of feeding is not sufficient for larger Friesian animals. Crossbred heifers are expected to be heavier than the average of their parental breeds due to the effects of heterosis. The effect of heterosis has been estimated at 7.7 kg or around 1.7% of live weight, in Holstein Friesian x Jersey animals (Lopez-Villalobos et al. 2000). As a result of the effects of heterosis, live weight production values are higher than live weight breeding values, resulting in higher target live weights.

Table 1 Factors affecting 305-day milk volume, in Lactation 1 or Lactation 2, for heifers with a live weight measured between 15 and 17 months or between 18 and 21 months and a lactation length of >80 days. Estimates of the effect on annual milk production ± standard error of the mean, of a one unit change in the percent of target live weight are given. Bold text indicates significance at P <0.05.

Age at live weight measurement	Lactation number	Model R^2	Region effect	Breed effect	Percent of target live weight effect	
			P value	P value	Mean	P value
15–17 months	1	0.61	0.34	**<0.001**	18.6 ± 0.6 L	**<0.001**
	2	0.54	**0.005**	**<0.001**	21.3 ± 1.0 L	**<0.001**
18–21 months	1	0.64	0.19	**<0.001**	23.2 ± 0.6 L	**<0.001**
	2	0.61	**0.02**	**<0.001**	24.0 ± 0.9 L	**<0.001**

When setting targets for crossbred animals the use of live weight production values, rather than breeding values, would provide a more accurate estimate of mature live weight and therefore should be considered. A clear extension message is that all heifers need monitoring to ensure they are on target, with additional feeding if they are not on target.

The mean length of the artificial insemination period in a recent study was 42 days (Brownlie 2013). After allowing for variation in gestation length the expected birth date range for replacement heifers would be at least 50 days. Later-born heifers have less time to reach their target live weight than an early born herd mate. This is likely to explain the relationship between calving date and percentage of the target live weight achieved found in the current study. Mechanisms to improve growth rates in later born heifers, or to improve herd reproductive performance so late-born heifers do not need to be retained, should be investigated to provide information to farmers.

In heifers with a live weight recorded from two months prior to one month post the planned start of mating, a small effect of pre-mating live weight on calving pattern in the first lactation was found. The small size of the effect is likely due to heifers reaching puberty at around 45–50% of mature live weight (Garcia-Muniz 1998; McNaughton 2003), whilst the pre-mating target is 60% of mature live weight. Even heifers that are only 85% of their target live weight are likely to have reached puberty by the start of mating. An additional factor that can diminish the effect of pre-mating live weight on calving pattern is the use of synchrony treatments in heifer artificial insemination programmes. Synchrony treatments with a progesterone component can induce ovulation in pre-pubertal heifers. Between 100,000 and 200,000 yearling heifers are artificially inseminated each year (DairyNZ 2012).

Heifer live weight prior to calving has been demonstrated to have a significant effect on milk production in previous studies, both in New Zealand (MacDonald et al. 2005; van der Waaij et al. 1997) and overseas (Carson et al. 2002; Dobos et al. 2001). If a 9% milk solids test is assumed, the expected response is about two kilograms of milk solids per lactation for every one percent increase in target live weight attained. For a heifer with a pre-calving target of 500 kg, five kilograms is equal to one percent of live weight. Van der Waaij et al. (1997) reported a response of 6 L of milk and 0.43 kg of milksolids per kg of live weight, whilst Dobos et al. (2001) reported 5.35 litres of milk and 0.42 kg of milksolids per kg of live weight at first calving. Multiplying these values by 5, for a 5 kg advantage, gives 26.8–30 L of milk and 2.1–2.15 kg of milk solids for every 1% increase in live weight attained, similar to the level of response reported here. Feed intake was estimated to increase by 6 kg dry matter for every kg of liveweight gain in a 400 kg heifer (van der Waiji et al. 1997). Thus each 1% gain in live weight would cost approximately 30 kg of dry matter and return approximately 2 kg of milk solids in each of the first and second lactations. If the on-going maintenance costs of this liveweight gain are ignored, the breakeven cost per kg of dry matter is 40c, at a milksolids price of $6/kg. A full economic analysis of the costs and benefits of liveweight gain in heifers would require quantification of benefits aside from the milk production response and costs of maintaining the additional live weight. This would provide farmers with the information they require to make decisions about heifer feeding levels and the economics of supplementation to increase growth rates. This should be a priority for future work in this area.

Data, linking pre-calving live weight and reproductive performance, is limited as many studies that have investigated different growth regimes do not have the statistical power to detect differences in reproduction traits. The results from the current study suggest there is a positive relationship between heifer live weight and the likelihood of first calving and recalving. Further investigation into the relationship between heifer live weight and reproductive performance would be valuable, particularly in examining the relationship between heifer live weight and first lactation reproduction performance.

This study has demonstrated that breed, region, herd and birth year are able to explain some of the variation in heifer live weight. Herd was the most important factor in explaining variation in heifer live weight, suggesting that management is the most important influence on heifer live weight. Heifers that were a lower proportion of their target live weight produced less milk and were less likely to calve for the first time, or to recalve a second time. Analysis on data from the National Herd Fertility Study will further explore the relationship between heifer live weight prior to calving and reproductive performance. This will provide more detailed fertility phenotypes than can be obtained from the national database.

References

Brownlie TS 2013. Quantifying the effect of the InCalf Farmer Action Group on seasonal-calving pasture-based dairy farms in New Zealand. PhD thesis. Massey University, Palmerston North, New Zealand.

Bryant JR, Holmes CW, Lopez-Villalobos N, McNaughton LR, Brookes IM, Verkerk GA, Pryce JE 2004. Use of breeding values for live weight to calculate individual targets for dairy heifers. Proceedings of the New Zealand Society of Animal Production 64:118–121.

Carson AF, Dawson LER, McCoy MA, Kilpatrick DJ, Gordon FJ 2002. Effects of rearing regime on body size, reproductive performance and milk production during the first lactation in high genetic merit dairy herd replacements. Animal Science 74: 553–565.

DairyNZ 2012. New Zealand dairy statistics 2011-12. DairyNZ, Hamilton, New Zealand. 50p. http://www.dairynz.co.nz/file/fileid/45159 [accessed 13 May 2013].

Dobos RC, Nandra KS, Riley K, Fulkerson WJ, Lean IJ, Kellaway RC 2001. Effects of age and liveweight at first calving on first lactation milk, protein and fat yield of Friesian heifers. Australian Journal of Experimental Agriculture 41: 13–19.

Garcia-Muniz JG 1998. Studies of Holstein-Friesian cattle bred for heavy or light mature live weight. PhD thesis, Massey University, Palmserston North. New Zealand. 269p.

Hayes D, MacDiarmid B, Wickham I, Burton L 1999. Some effects of live weight, breed and management on the reproductive performance of replacement dairy heifers. Proceedings of the 16th Annual Seminar of the Society of Dairy Cattle Veterinarians of the New Zealand Veterinary Association. 93–104.

Lopez-Villalobos N, Garrick DJ, Holmes CW, Blair HT, Spelman RJ 2000. Profitabilities of some mating systems for dairy herds in New Zealand. Journal of Dairy Science 83: 144–153.

MacDonald KA, Penno JW, Bryant AM, Roche JR 2005. Effect of feeding level pre- and post-puberty and body weight at first calving on growth, milk production and fertility in grazing dairy cows. Journal of Dairy Science 88: 3363–3375.

McNaughton LR 2003. A comparison of reproductive performance and physiology of three genotypes of Holstein Friesian dairy cattle. PhD thesis. Massey University, Palmerston North, New Zealand. 239p.

McNaughton LR, Lopdell T 2012. Are dairy heifers achieving liveweight targets? New Zealand Society of Animal Production 72:120–122.

R Core DevelopmentTeam 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org/. [accessed 8 May 2013].

SAS 2012. JMP Version 10.0. SAS Institute Inc., Cary, North Carolina, USA.

van der Waaij EH, Galesloot PJB, Garrick DJ 1997. Some relationships between weights of growing heifers and their subsequent lactation performances. New Zealand Journal of Agricultural Research 40: 87–92.