Quantifying the effect of the InCalf Farmer Action Group on seasonal-calving pasture-based dairy farms in New Zealand

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Abstract

Dairy herd reproductive performance is purportedly in decline in New Zealand and internationally. The aetiology is multifactorial and complex and a broad range of hypotheses for this decline have been proposed, including cow and herd factors. An effective dairy industry needs optimal reproductive performance to maintain cattle welfare and a competitive advantage in the international marketplace. Six key herd-level management factors were identified as being associated with the reproductive performance in Australian seasonal-calving pasture-based dairy herds. A reproductive extension programme was built around these findings designed to enable farmers to improve reproductive performance on farm (InCalf). In 2008, the New Zealand dairy industry adapted InCalf for New Zealand conditions and made it available to dairy farmers and rural professionals. Coinciding with this programme development, the New Zealand dairy industry also set a national target of a herd-level average of 78% of cows pregnant by day 42 of the seasonal breeding period (6 week in-calf rate) by 2016. The last benchmarking of reproductive performance in the New Zealand dairy herd was undertaken in 1999-2000 and the first aim of this thesis was to estimate the current national-level for reproductive performance. Secondly, the effectiveness of farmer participation in the InCalf extension programme was quantified using a randomised controlled study.

This study found a 67% mean 6 week in-calf rate over both 2009/10 and 2010/11 study years amongst those herds allocated to a control group, reflecting similar findings to the previous benchmarking study. Although this finding suggests that overall reproductive performance has remained similar over the decade, conception to first mating (first service conception rate) has declined by 5% to 48% while the rate of breeding in the first 21 days of mating (3 week submission rate) has remained similar at 81% suggesting that the submission rate in the second 21 days of breeding has improved to account for the decline in first service conception rate. Change in behaviour in key management factors is needed in order to improve 6 week in-calf rate. Baseline interviews with farmers found general satisfaction with reproductive performance. This is a potential barrier to improvement, since dissatisfaction is needed to create the tension for change hypothesised to drive behavioural change.

This randomised controlled study found that farmer participation in regional InCalf extension programmes resulted in an average 2% improvement in reproductive performance during the year

of the intervention over herds where farmers did not participate ($p = 0.05$). The greatest effect was seen in the lowest performing herds and these should become the focus of future extension.

Herds participating in the InCalf extension programme had a significant improvement in heifer live-weight, premating mean body condition score and oestrus detection over herds that did not participate ($p < 0.05$). No significant difference was found in the distribution of calvings, anoestrous cow management or bull management. Improvements in the InCalf programme to achieve behaviour change for those management factors where the current InCalf has not proved effective may lift performance and further work is needed to evaluate the extent of the effect of participation on attitude change.

The industry must now decide if this is sufficient improvement in reproductive performance to invest further in this model of extension and whether to improve it using the recommendations from this thesis.

Acknowledgements

I arrived in New Zealand in 2007 as a dairy veterinarian with the intention to complete the Masters course in epidemiology offered by Massey University to improve my effectiveness as a vet. I did not expect this would lead to completing a doctoral thesis or running a national herd fertility study. On both counts I am very surprised and extraordinarily lucky! It has been a unique opportunity and its completion would have been improbable without the help from a large number of people and I am grateful for the opportunity to thank them!

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Abbreviations

KASA	Knowledge, Attitude, Skills and/or Aspirations
KDM	Key decision maker
LIC	Livestock Improvement corporation
MSD	Mating start date
PSC	Planned start of calving
PSM	Planned start of mating
RCT	Randomised Controlled Trial

List of Publications

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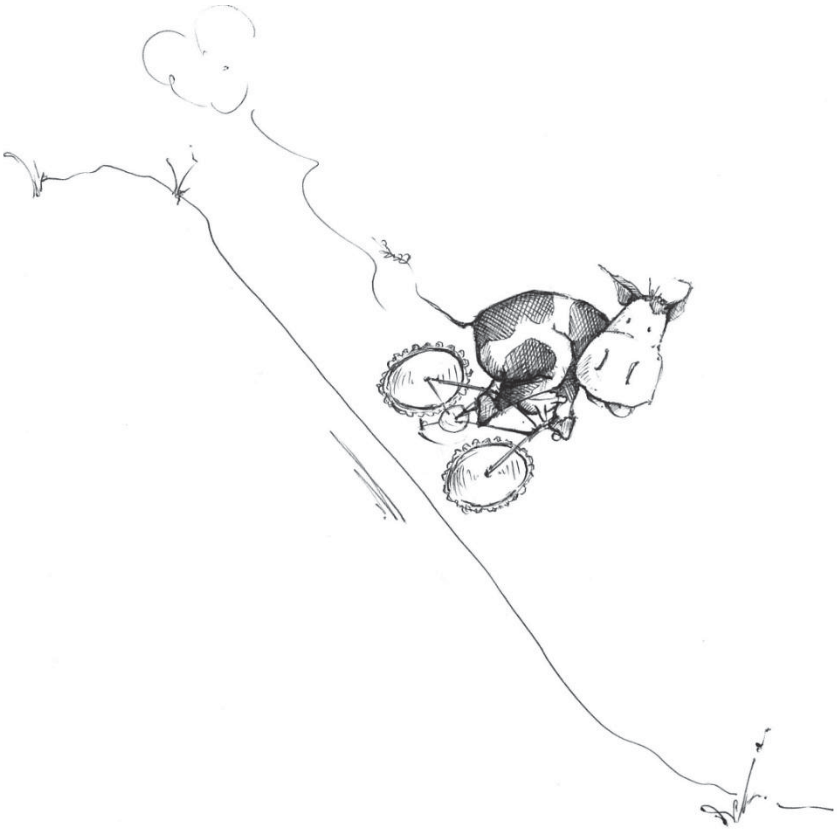

Getting cows cycling faster…

CHAPTER 1

Introduction

‘Make two blades of grass grow where one grew before’

Porter (2008, p308, cited from Arthur Young 1767)*

Making cows produce more calves and more milk than before is a laudable ambition, even if it is downstream of making the grass grow better.

In the seasonal calving, and hence breeding, system commonly used in New Zealand, optimising reproductive performance is likely to be a key determinant of farm function and profitability (Macmillan, 2002a). The reproductive performance of the dairy herd has apparently been in decline over the last 20 years both in New Zealand (Harris, 2005) and internationally (Friggens *et al.*, 2010; Lucy, 2001). However, previous New Zealand data have limitations in that they have based either on measures that were not necessarily comparable between herds (e.g. proportion non-pregnant; ‘empty rate’), subject to measurement bias (assumption of pregnancy based on no detectable subsequent oestrus events), involved retrospective analysis of data and/or had potential biases in herd or region selection. This thesis provides the most precise description of reproductive performance in the New Zealand national herd. Such data is important as it provides the most reliable basis to make informed decisions about reproductive performance at a national level.

The InCalf herd reproduction extension programme for dairy farmers was launched in Australia in 2003 (Britton A, 2003) in an attempt to reverse the decline in reproductive performance in Australian dairy herds. This program included delivery of structured and facilitated meetings (Farmer Action Groups), decision support systems (e.g. benchmarking tools), one-to-one consultation with trained advisors and provision of a comprehensive technical manual. A memorandum of understanding with DairyNZ allowed the adaptation of the program for New Zealand conditions. InCalf was launched in New Zealand in 2008 (Blackwell, 2008). Alongside this launch, stakeholders set an industry target to achieve a national average 6 week in-calf rate of 78% by 2016.

*Young used this quote from the King of Brobdingnag (“Gulliver’s Travels”) as the charter for the first publicly funded Board of Agriculture in England

The efficacy of the InCalf program has not been formally evaluated either in Australia or New Zealand. Given the significant investment by the dairy industries and rural professionals of the two countries in the programme for more than 5 years; it is now appropriate to critically evaluate the program to assess its efficacy and to identify areas for improvements.

This thesis was developed to: quantify the current reproductive performance of New Zealand dairy herds, to quantify effect of New Zealand dairy farmer participation in the InCalf reproduction extension program in the form of the Farmer Action Group and to describe farmer attitudes and behaviours concerning reproductive performance.

The Collins English Dictionary defines attitude as “the way a person views something or tends to behave towards it, often in an evaluative way” (Anonymous, 2012). This review uses this definition of attitude to encompass, farmers views beliefs and/or motivations. In subsequent chapters; attitude, priorities and perceived constraints are dealt with separately.

This review places the research chapters of this thesis in context of previously published and related work and attempts to answer three questions: Why an extension programme was required to improve the reproductive performance of the New Zealand dairy herd; how it was designed to enable change in reproductive performance and; what methods are appropriate to evaluate the impact of such an extension program.

The New Zealand dairy industry and herd reproductive performance are first described in order to contextualise the work within this thesis. The evolution of international agricultural extension, including current extension philosophy and models of extension are reviewed. The process used by the InCalf herd reproduction extension programme is considered as a current model of extension. Finally, studies evaluating extension programmes are outlined using a hierarchy of criteria, thereby establishing the study design use within this thesis to quantify the effect of the *InCalf* reproductive extension programme on herd-level reproductive performance of seasonal-calving pasture-based dairy herds in New Zealand.

1.1. New Zealand Dairy Industry

1.1.1. *History of the New Zealand Dairy Industry*

In 1815, Reverend Samuel Marsden imported a dairy bull and two heifers into Russell from Sydney, the first recorded arrival of dairy animals into New Zealand (Holmes and Wilson, 1984). A slow increase in the number of imported dairy stock continued over the next 30 years and, by 1846, commercial milk production allowed the first exports of butter and cheese to Australia. In 1882, the first refrigerated shipment of meat and butter left Dunedin for London. A world-first, this shipment was the advent of a substantial export trade to the United Kingdom which continued until the 1970's, when the United Kingdom joined the European Union. Despite this, New Zealand Anchor butter remains the top branded butter in the United Kingdom.

The establishment of a cheese company on the Otago Peninsula in 1871 represented the first dairy processing co-operative in New Zealand. By the 1940s, more than 400 dairy co-operatives were operating throughout the country. The co-operatives primarily supplied the export market, with an international marketing arm subsequently established within the Dairy Export Produce Control Board (later becoming the New Zealand Dairy Board).

Between 1930 and 1960, farming innovation increased and transport and refrigeration technology improved. The first electric fence was used in 1938; the first milk tanker collection occurred in 1951 and, by 1955, on-farm milk cooling had been introduced. This technology accompanied a substantial reduction in dairy co-operatives (409 in 1941 reduced to 12 by 1996). A period of consolidation within the dairy industry preceded the introduction of the Dairy Industry Restructuring Act (2003), which brought further structural reform. A statutory monopoly of power formerly held by the New Zealand Dairy Board was removed on dissolution of that body, allowing the co-operative Fonterra to become established as the country's international marketing presence (Conforte *et al.*, 2008). This has been followed by a period of increasing industry growth and change.

Dairy cow numbers in New Zealand increased steadily from 1.7 million (in 40,000 herds) in 1945 to 2.3 million cows (in 25,000 herds) in 1969. As illustrated in Figure 1, cow numbers increased by 21% from 2003 to 2011, (3,740,637 to 4,528,736) (Anonymous, 2011) and the average New Zealand national dairy herd size increased to from 180 animals in the 1992/93 season to 386 animals in the 2010/11 season. This shift to a larger average herd size but lower total number of herds reflects a similar trend toward consolidation internationally, apparently due to the economy of larger scale (Hemme, 2011; Jago and Berry, 2011).

Similarly, an increase in the genetic potential of the national New Zealand dairy herd, accelerated through selective breeding and improved insemination, was also reflected in increased milk yield and production of milksolids (Figure 1.1).

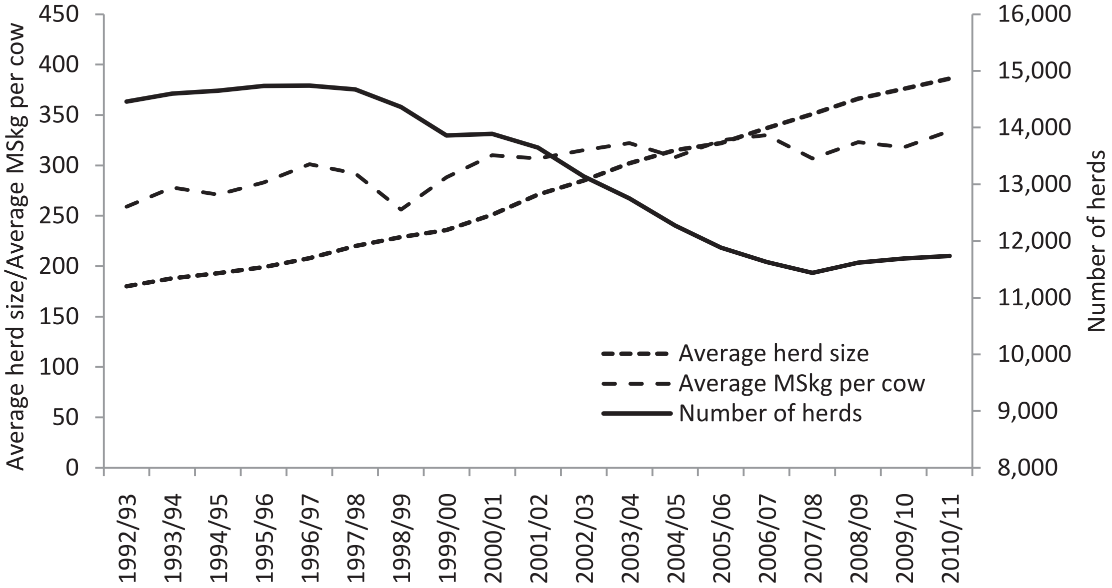

Figure 1.1. National annual statistics of herd numbers, average herd size and average milk solid (kg) per lactation of New Zealand dairy herds (Taken from National Dairy Statistics 2010-11)

Currently 4.25 million dairy cows are milked in New Zealand on approximately 11,000 farms (Anonymous, 2011; Figure 1.1). Capitalising on New Zealand's temperate climate and relatively extended grass-growing season, over ninety percent of New Zealand dairy herds operate a predominately pasture-based farming system (Verkerk, 2003). However, this low-input, pasture-based system also presents a unique set of challenges for the industry. Foremost, a seasonal and compact annual calving period is necessary to align the nutritional demands of the herd for energy and protein for milk production with the pattern of pasture quality and quantity. A planned start of calving date is set at the herd-level to align peak production with peak pasture growth and the preceding planned start of mating (PSM) is calculated accordingly. To achieve optimal reproductive performance in such a system, a high proportion of the herd must be bred and conceive early in the seasonal breeding program (Macmillan, 2002b).

The seasonal-calving system requires different measures of reproductive performance than commonly used in non-seasonal-calving systems (Morton, 2010). The primary measures of reproductive performance used within seasonal-calving systems are the 6 week in-calf rate (the proportion of a herd pregnant to first 42 days of the mating period) and final pregnancy rate (the proportion of animals pregnant as a result of the whole mating period). Convention has falsely referred to these proportions as rates, for readability, these measures will be referred to as rates within this thesis although a better term may be in-calf risk. Traditionally, reproductive performance has been measured using the not-in-calf rate or ‘empty rate’, the inverse of the final in-calf rate. This measure is closely associated with mating duration and culling decisions making direct comparison between herds inappropriate. Pregnancy rate measures in turn are dependent on the submission rate and conception rate of the herd. These variables are calculated as the proportion of animals with at least one breeding event in a fixed time period, commonly the first 21 days of mating (3 week submission rate) and the proportion of animals that conceive to their first breeding event (first service conception rate). Submission rate was first identified as a driver of in-calf rate in 1973 (Macmillan and Watson, 1973). Preceding this, conception rate was considered the key driver of in-calf rates. Challenges to measuring these include knowing the population, precise pregnancy testing data and knowledge of reproductive status of cows lost from the population during the breeding program.

The economic effects of poor reproductive performance have been quantified using a farm system model (Burke *et al.* 2008; Beukes *et al.* 2010). A 1% decline in 6 week in-calf rate and a 1% increase in non-pregnant rate at the end of the breeding season (relative to targets) are calculated to cost $4 and $10/cow/annum respectively. At national level, suboptimal reproduction is likely costing the New Zealand dairy industry hundreds of millions of dollars per annum.

1.1.2. *Declining reproductive performance of New Zealand Dairy Industry*

The reproductive performance of the New Zealand dairy herd has reportedly been in decline (Harris, 2005). A longitudinal analysis of the National Dairy Database (currently managed by the Livestock Improvement Corporation (LIC)) found the percentage of lactation 2 to 4 cows that re-calved within the first 42 days of the calving period declined from an average of 70% in 1991 to 50% in 2001 (Figure 1.2) (Harris, 2005). It was hypothesized that this decline was due to a concurrent decline in conception rate (proportion of inseminations that result in a confirmed pregnancy) as the submission rate increased marginally during the 14 study years. A 42 day calving rate was used in this study as a proxy measure for the 6 week in-calf rate as no pregnancy diagnoses were available for this retrospective study.

In 1999, the New Zealand dairy industry levy board (Dairy Insight now DairyNZ) recognised the apparent downward trend in reproductive performance within the New Zealand dairy herd and accepted responsibility to reverse this trend. DairyNZ adopted a national mean target 6 week in-calf rate of 78% (to be achieved by 2016 with minimal hormonal intervention) as a component of the

National Dairy Strategy (Anonymous, 2010). This target was based on the mean 6 week in-calf rate of the top quartile of herds in a 1998-2000 benchmarking study (Xu and Burton; 2003). Similarly, targets of 90% and 60% were set for three week submission rate and first service conception rate, respectively, based on the top quartile of these herds. Currently, there is no on-going national herd-level measure of reproductive performance against which the industry can benchmark its performance. As a consequence, the analysis in Chapter 3 of this thesis was undertaken. Since the dairy industry has adopted the 6 week in-calf rate as the principal measure of reproductive performance, this thesis makes no attempt to report other measures of herd-level reproductive performance.

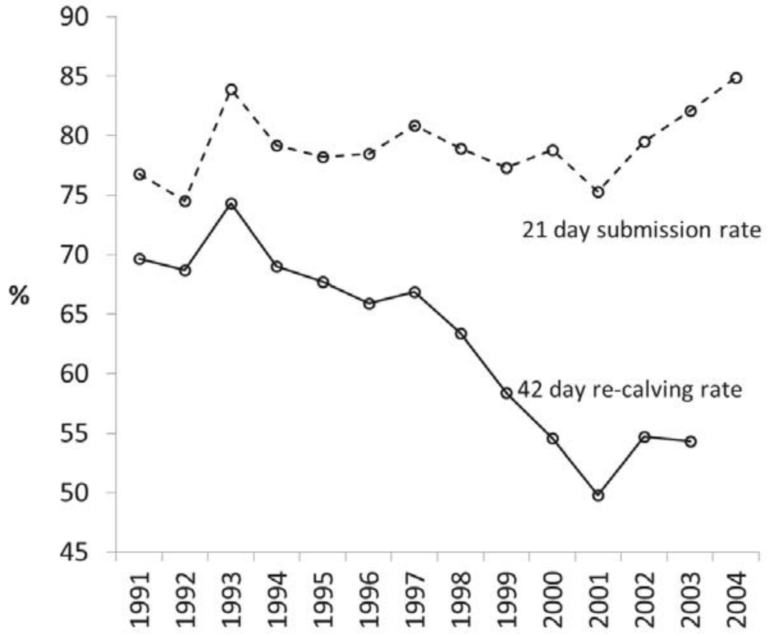

Figure 1.2. National trends in 21 day submission rate (dashed line) and 42 day re-calving rate in the New Zealand dairy herd based on the National Dairy Database. (Harris *et al.,* 2005). Re-calving rate was used as a proxy measure for the proportion of animals pregnant by 42 days after mating start date (6 week in-calf rate)

1.1.3. *Herd level risk factors for reproductive performance*

The decrease in reproductive performance has been largely, but not entirely, attributed to a decline in cow fertility. The aetiology of this decline in cow-level fertility is multifactorial and has been well investigated at animal, organ and cellular level (Evans and Walsh, 2012; Walsh *et al.*, 2011). There are extensive published reports of the risk factors for reproductive performance at cow and lactation-level, both in New Zealand and overseas, but fewer studies have evaluated the effect of herd-level management policies. This review does not discuss the current work on cow-level risk factors in depth. It is included to place the herd level risk factors in context.

Physiologically speaking, risk factors for cow-level fertility can be split into pre-ovulatory and post-ovulatory risk factors. Risk factors affecting the immediate pre-ovulatory period manifest as reduced oestrus behaviour or a delayed return to oestrus post-partum (anovulatory anoestrus; Rhodes *et al.*, 2003). Key risk factors in this period include extended or severe negative energy balance post-partum (Butler, 2005; Roche *et al.*, 2007) or poor uterine health (LeBlanc, 2008). At a herd-level these can present as a reduced herd submission rate. Risk factors affecting the post-ovulatory period affect fertilization and at a herd-level can present as a reduced conception rate. Key risk factors in this period again include poor uterine health (McDougall, 2001b), low progesterone secretion or poor oocyte quality (Evans and Walsh, 2012) and the sensitivity and specificity of oestrus detection. Genetic selection for increased milk yield or composition is implicated for a decline in fertility. However the relationship has not been consistently described: Several studies have shown negative phenotypic relationships between milk yield and reproductive performance (Hoekstra *et al.*, 1994; Royal *et al.*, 2000), conversely, experimental evidence from New Zealand studies reported a positive relationship between milk composition (chiefly percent protein in milk) and reproductive performance (McDougall *et al.*, 1995; Xu and Burton, 2003). The latter relationship suggests that milk solids yield is not a limiting factor on phenotypic reproductive performance.

The international downward trend in herd-level reproductive performance has been the focus of recent debate (Barbat *et al.*, 2010; Evans *et al.*, 2006; Leblanc, 2010), specifically the validity of the primary data from which the inference of declining reproduction has been based. LeBlanc (2010) and Morton (2006) identified several potential biases within the datasets of early trials that reported declining national dairy reproductive performance (Butler, 1998; Lucy, 2001; Royal *et al.*, 2000). The principal concern was the risk of confounding through unmeasured production, genetic and management factors that may have accounted for the apparent decline in cow-level fertility.

At a herd-level, risk factors have been identified that directly affect cow-level fertility such as the effect of low average body condition score on both anoestrus and poor oocyte quality (Roche *et al.*, 2009). Other risk factors do not act directly on cow-level fertility but are key risk factors for herd productive performance such as calving pattern in a seasonal-calving system. Herds with cows calving over a longer period have a higher number of cows with shorter intervals between calving and the onset of mating (Macmillan, 2002a). All cows are considered ‘at risk’ of pregnancy following mating start date (MSD) and cows detected in oestrus on or after MSD are inseminated, regardless of the proximity of calving to MSD. However, cows that calve later in the calving season and hence have shorter intervals from calving to first mating have lower conception (and pregnancy) rates than those that calve earlier in the calendar year. Management policies that govern the calving pattern of the herd include removal or hormonal induction of late conceiving cows (Compton and McDougall, 2010), preferential purchase of early conceived cows and the early conception of replacement heifers.

Seasonal-calving dairy systems are also at particular risk from poor fertility associated with suboptimal body condition score at calving (Burke *et al.*, 2005, Berry *et al.*, 2007) and loss of body condition in early lactation which have an negative effect on both submission and conception rates (Pryce *et al.*, 2001). Recent reviews of body condition score highlighted the impact of post-partum energy balance on reproductive performance, post-partum anoestrus and oestrus detection (Rhodes *et al.*, 2003; Roche *et al.*, 2009; Stockdale, 2001). Anecdotal evidence suggests that farmer perception of the BCS of their herd often conflicts with that of independent scores and that BCS is not commonly undertaken in dairy herds. Roche *et al.*, (2007) found that cows with a >0.3/5 condition score loss following calving were 1.17 times less likely to conceive than cows that lost no BCS after calving.

The short mating period in seasonally-calving systems places considerable demand on the sensitivity and specificity of oestrus detection (McDougall, 2006). Cows undergoing first post-partum ovulation, heifers or higher parity cattle (>8 years), Friesians, those cows with peripartal disease and those calving later in the calving period have lower submission rates than the remainder of the herd (Burke *et al.*, 1995; Rhodes *et al.*, 1998). Consequently, the highest probability of being detected in oestrus in the first 21 days after MSD is generally among early-calved, mature cows.

One quarter of seasonally-calving farmers studied as part of the Australian Dairy Herd Fertility Project had an oestrus detection sensitivity of <0.91 when compared to results of plasma progesterone assay suggesting that oestrus detection contributed to poor reproductive performance in these herds (Morton and Wynn, 2010). The technique most commonly employed for oestrus detection in seasonally-calving New Zealand dairy herds involves abrasion of tail paint (Macmillan and Curnow, 1977) or compression or abrasion of tail mounted beacons through mounting. The current recommendation is to apply an oestrus detection aid 35 days in advance of MSD to provide adequate time to identify and manage cattle in anoestrus.

Anoestrus has been well recognised as a significant problem in New Zealand dairy herds (Rhodes *et al.*, 1998; McDougall, 2001b; Chagas *et al.*, 2007). The New Zealand dairy industry strategy requires minimal hormonal intervention in the pursuit of the national target for reproductive performance

(Anonymous, 2010). It should be assumed that this is intended at both a lactation and herd level. Between 13 and 48% of cows have been reported in anoestrus between 50 to 60 days post-partum (Rhodes *et al.*, 2003) and hormonal intervention for anoestrus has been reported in 81% of herds (Xu and Burton, 2003). A current cost benefit analysis for herd-level anoestrus intervention suggests the most cost effective intervention is undertaken in advance of MSD rather than traditionally treating a smaller number later in the mating period (McDougall, 2010a). This method yields a higher conception rate despite a greater proportion of the herd being treated for anoestrus.

Replacement heifer management has also been identified as a risk factor for future herd reproductive performance. A recent preliminary study of the New Zealand National Dairy Database found a significant number of heifers failing to achieve target weights (McNaughton and Lopdell, 2012). Pre-calving heifer live-weights have been identified as key performance indicators for young stock management yet weighing young stock periodically to assess the live weight is not yet common practice in New Zealand (McNaughton *pers comm*). Heifer weight is likely to have some effect on subsequent herd fertility as replacement heifers that do not meet body weight targets at key times during rearing have slower onset of puberty (Macdonald *et al.*, 2005), lower submission rates in first lactation (Burke *et al.*, 1995; Hayes *et al.*, 1999) and lower 6 week in-calf rate (Morton, 2003b).

Beukes *et al.*, (2010) used a stochastic simulation model of New Zealand dairy farms to identify the natural bull mating period as the area with the greatest opportunity for reproductive improvement. However, despite this, little current work has been undertaken to investigate bull management practices in seasonally-calving herds in either New Zealand or internationally. Given the common management practice in New Zealand of undertaking artificial insemination upon detection of oestrus for a period of 4 to 6 weeks after the PSM, and thereafter placing intact bulls with the herd for the remaining 8 weeks or so of the breeding program, insufficient numbers of bulls, subfertile bulls or diseased bulls may have large impacts on the herd fertility.

1.1.4. *New Zealand Monitoring Fertility Project (1998-2000)*

The most recent multi-herd benchmarking study of dairy herds in New Zealand involved 101,185 cows from 206 herds (contributing 414 herd-years) over a period of three years; 1998 to 2000 (Xu and Burton, 2003). The majority of study herds (323 of 414 study-years; 78%) had qualified to participate in a genetic improvement scheme for the Livestock Improvement Corporation (LIC; Sire Proving Scheme), while the remainder were selected from the Waikato and Taranaki regions in the North Island. Outcome measures analysed were 21 day submission rate (3 week submission rate), first service conception rate, 6 week in-calf rate, final in-calf rate (inverse of the final empty rate) and anoestrus rate.

The primary objective of the 1998-2000 study was to benchmark these reproductive outcomes and investigate associations with selected lactation-level biophysical factors, such as season, cow age, cow breed, and interval from calving to PSM and herd-level management factors, such as farm owner age, education level and number of labour units.

Table 1.1. Pooled herd-level outcome measures of reproductive performance of 206 distinct herds enrolled in the New Zealand Monitoring Fertility Project between 1998 and 2000

	Mean of lower quartile	Mean value[a]	Mean of upper quartile
21 day submission rate	66.9%	81.0%	91.3%
First AI conception rate	43.4%	53.0%	62.3%
6 week in-calf rate	57.4%	68.2%	77.8%
Final in-calf rate[b]	82.8%	90.0%	95.1%

[a] Mean values, rather than median alongside quartiles, were reported in the study
[b] More commonly, the final not-in-calf rate (inverse of final in-calf rate) is used as a key performance indicator by dairy farmer. However, mating duration and culling strategies make comparison inappropriate

Herd level management factors were collected through farmer interviews and analysed against herd level outcome measures: Owner-age, formal education, number of mobs of cows within a herd, number of labour units, use and timing of anoestrus treatment, number of staff responsible for oestrus detection, whether owner, herd manager or labour undertook oestrus detection. Other variables were herd size and average 305 day milksolid yield derived from the herd testing records. Season, region and participation in the sire proving scheme were included as fixed effects to account for their effect on other explanatory variables.

The herd-level results pooled across all study years suggested that New Zealand dairy herd reproductive performance was high relative to those published internationally (Friggens *et al.*, 2010; Lucy, 2001; Royal *et al.*, 2000). However, there was a wide range in between-herd performance, with a greater than 20% interquartile range in 6 week in-calf rate (Table 1.1).

The 1998-2000 study confirmed a number of associations between reproductive performance and lactation-level risk factors, including breed (also shown by MacMillan, 1996; Cue *et al.*, 1996), anoestrus at the beginning of the breeding season (Hanlon *et al.*, 2000; McDougall, 2010a; Rhodes *et al.*, 1998) and a curvilinear relationship with cow age. However, this study failed to identify any significant herd-level management factors that were predictive of overall herd reproductive performance. Despite this, minor trends were identified, such as an improved submission rate where fewer people were tasked with the responsibility of detecting cows in oestrus.

The preferential selection of those herds that were eligible for the Sire Proving Scheme may have introduced selection bias as the scheme was voluntary and required a high level of stockmanship and data recording. This may have introduced higher estimates of performance if the herd selection criteria correlated with better reproductive performance. Furthermore, herd-level pregnancy diagnosis was not mandated and the date of conception was based on a combination of pregnancy testing at an undefined, and perhaps less than optimal time, and estimation of date of conception based on subsequent calving date less 282 days (the length of gestation). Approximately 3% of cows were culled or died before pregnancy diagnosis and hence were lost to follow up. Current best practice to age pregnancy in dairy cattle is through the use of transrectal ultrasonography of the reproductive tract by a trained professional between 35 and 90 days post-insemination (Morton, 2010). Estimates of the stage of gestation can occur outside this time range but the specificity of diagnosis decreases as the fetus descends into the abdomen and out of the range of the transrectal ultrasound probe (McDougall *et al.*, 2005). It is not clear to what extent the assumptions about date of conception used in this study may have affected the calculated pregnancy rates.

If both selection bias and assumption of conception introduced bias, the final outcome results were likely higher than the true national values. To accurately measure future national dairy reproductive performance, a more representative sample of the New Zealand dairy industry and accurate diagnosis of conception date would be required.

1.1.5. *Australian Dairy Herd Fertility Project (1996-2003)*

The Australian Dairy Herd Fertility Project (1996-2000), which preceded the 1998-2000 New Zealand Monitoring Fertility Project, was undertaken in response to farmer concerns about falling reproductive performance in Australian herds and funded by the Australian dairy industry levy body (Dairy Research and Development Corporation). The core objective of the project was to identify the major risk factors associated with between-cow and between-herd variation in reproductive performance (Morton, 2003b, 2004). The main project consisted of a prospective observational study of 29,462 cows in 168 seasonal and non-seasonal-calving commercial herds in nine regions of Australia.

The extensively reported study findings (Morton, 1999, 2000, 2003a, b) benchmarked and examined a large number of putative risk factors for Australian dairy herd reproductive performance. Due to the prolonged mating periods practiced in Australia compared to New Zealand, 6 and 21 week in-calf rates were used as principle outcomes measures to benchmark reproductive performance in Australian seasonal-calving herds, in contrast to 6 week in-calf rate and empty rate used in New

Zealand studies. This was the first study to compare the reproductive performance of seasonal-calving herds using a consistent measure.

A broader level of variation was reported in the 6 week in-calf rate of Australian dairy herds (63%; raw overall range 23% - 86%) than was identified in the 1998-2000 New Zealand study (68%; interquartile range 57% - 78%) (Xu and Burton, 2003). Based on these results, it was hypothesized that lower performing herds may improve their reproductive performance if key herd-level risk factors could be identified and reversed. The following key herd-level management factors were identified as major determinants of herd reproductive performance:

1. Calving pattern (the distribution of intervals from each cow's calving to herd mating start date);
2. Pre-calving heifer live weights;
3. Pre-calving body condition scores;
4. Oestrus detection;
5. Artificial insemination techniques; and
6. Bull management.

The data on these risk factors within the Xu and Burton study (2003) and other studies suggested that the risk factors identified by the Australian InCalf program were likely also associated with reproductive performance in New Zealand dairy herds.

1.1.6. *Extension programmes to improve herd fertility*

As reproduction is key determinant of herd productivity and economics there is a long history of extension programs designed to optimise herd fertility. In Australasia, programs were established in Victoria (Blood *et al.*, 1978; Morris *et al.*, 1978) and New Zealand (Davey, 1977; Jackman and Moller, 1977). Additionally there was development of software packages to enhance decision making by veterinarians (e.g. Dairyman; (Hayes and Morris, 1996; McKay, 1988)) and advice was provided to veterinarians interested in such programs (McKay, 1994, 2000; Williamson, 1994, 1996).

The InCalf dairy reproduction extension programme was developed based on the results of the Australian Dairy Herd Fertility Project (Britton *et al*., 2003). The results of the Australian Dairy Herd Fertility Project were initially reported nationally through a series of workshops where farmers were encouraged to accurately measure performance and to identify herd-specific risk factors. However, the effect of these workshops on national- or herd-level reproductive performance was not measured. Based on previous evidence of little to no effect on farm performance using this extension model (Black, 2000), little change could have been anticipated as a result.

A memorandum of understanding between the DairyAustralia and the DairyNZ allowed the InCalf extension programme to be adapted for the New Zealand dairy industry. The adaption involved a needs analysis survey of farmers and rural professionals (Burke *et al.*, 2008) and utilized data from the DairyNZ whole farm model (Beukes *et al.*, 2010). Using the results of the New Zealand Monitoring Fertility Project alongside expert experience from the New Zealand dairy industry, benchmark targets were set and resource material adapted accordingly. The programme was based on a process (informally referred to as a 'plan-do-review' process) that placed the farmer as the focus of the decision-making, design and implementation of an informed plan to improve reproduction and incorporated professional advisors and the service providers involved in reproduction (e.g. artificial insemination technicians) (Figure 1.3; Britton *et al.*, 2003).

It comprised of a four step 'continual improvement process for incremental gain':

1. Assess current reproductive performance
2. Identify key management areas where improvement would be most beneficial
3. Prioritize these actions and plan change (actions) based on robust evidence
4. Undertake actions (then review the outcomes of these actions and renewing plans if necessary to start again at 1)

(1) Assessment of current reproductive performance

Using data from the Australian Dairy Herd Fertility Project, an algorithm was developed to estimate 6 week in-calf rate and drivers of this measure (chiefly the three week submission rate and first service conception rate) based on calving and mating dates and the proportion of matings that did not result in a repeat mating in the subsequent 24 days (non-return rate) where available. This was incorporated into a one page summary report that provided a measure of performance that was consistent across herds: the Fertility Focus Report. The estimate was generated where accurate aged pregnancy diagnoses were not available. The Fertility Focus Report provided a means of rapidly and simply assessing performance within herd and between herds.

The algorithm used to estimate the six week in calf rate was not tested on external data and a potential for measurement bias may be present. Ideally, the 6 week in-calf rate measure would be obtained using optimally timed pregnancy tests rendering an estimate unnecessary.

This tool also allowed benchmarking of participants across a region or country, the first time that seasonal-calving herds had been consistently compared by reproductive performance within a region or country.

(2) Identifying key management areas where improvements could be made

Cost-benefit algorithms were developed for six of the key risk factors identified in Australia to allowed farmers and their advisors to quantify the gap in their performance from a target value. The cost-benefit algorithm use an estimate of the unit changes in 6 week in-calf rate and final not-in-calf rate and the regression coefficient of each risk factor on these outcome variables to derive a economic value.

(3) Prioritize these actions and plan change (actions) based on robust evidence

The InCalf book was developed with input from farmers, advisors and extension specialists and has been widely distributed to provide an agreed base of technical knowledge (InCalf Book for New Zealand Dairy Farmers; Burke C. *et al.*, 2007). It was designed to be used as a reference guide and alongside other advisors to formulate and prioritize actions to improve. Formally planning actions has been shown to increase the likelihood of compliance (Gollwitzer, 1999).

(4) Undertake actions

Following undertaking actions, a systematic process of review is encouraged among trained InCalf providers; however, this is at the discretion of the participating farmer and their advisor.

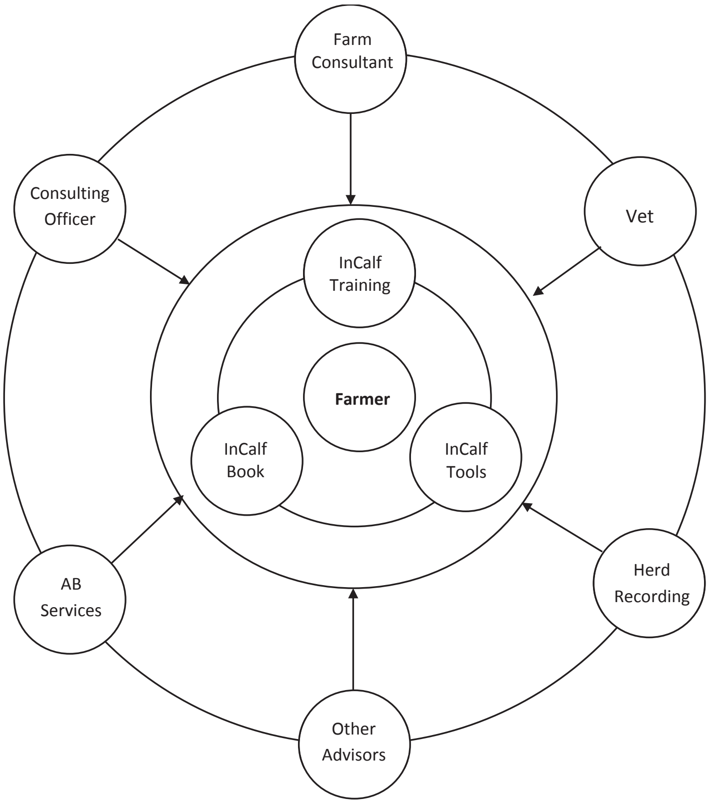

Figure 1.3: Diagram used to describe the farmer-centric model employed by the InCalf Farmer Action Group

1.1.7. *InCalf Farmer Action Group*

To deliver the InCalf process, a series of facilitated meetings were developed to address each one of four critical periods in the seasonal-calving year: calving, mating, mid/late lactation and dry period (Figure 5.1). These meetings were termed ‘Farmer Action Groups’. At the start of each of these periods a prepare session was held where the first three stages of the InCalf process could be undertaken in facilitated farmer discussion groups. At the end of period, a formal facilitated review session was held allowing farmers to discuss the results of their planned actions and propose improvements if necessary for the following season. Rural professionals were trained to act as facilitators for the farmer action groups. This training focused not only on the technical material, but more importantly on the process of facilitating the farmer action groups. A key focus of this training was for rural professionals to change from ‘top down’ technical advice providers to facilitators. A lower level of training was provided for ‘advisors’ to allow them to use the materials of InCalf, but not to run Farmer Action Groups.

Based on the literature reviewed in this section the InCalf Farmer Action Group model was considered to be the most effective model for extension thus it was farmer participation in the InCalf Farmer Action Group that was formally evaluated against a non-participatory control group in this thesis. The following sections expand on this hypothesis.

1.2. Agricultural extension

1.2.1. *Changing role of agricultural extension*

There is no widely accepted definition of agricultural extension. Relevant literature focuses on differing components of the overall process of extension; the transfer of information, enabling change and building farmer capacity to make their own decisions (Black, 2000). For example, the Food and Agriculture Organisation (FAO) of the United Nations suggest that “…extension [is] the organized exchange of information and the purposive transfer of skills” (Nagel, 1997) while the Australasian Pacific Extension Network (APEN) suggests that extension involves the “…process of enabling change in individuals, communities and industries involved in the primary industry sector and with natural resource management”.

The earliest example of agricultural extension was recorded on clay tablets in Mesopotamia (c.1800 BC), with advice on watering crops and rodent control (Swanson, 1984); quoting from (Bne Saad, 1990). It has been hypothesized that this advice, written by a central taxation body, was provided to mitigate the potential loss of taxable revenue from farmers. Jennings (2007) used this example to develop a modern definition of “agricultural extension” which included the necessary link between ‘off-farm agricultural domains’ (such as the Mesopotamian taxation body), and farmers.

Furthermore, Jennings contended that other, early examples of agricultural advice, including Egyptian, Greek, Roman and Chinese examples did not operate as a link between on- and off-farm domains of agriculture and, so, did not meet her modern definition of agricultural extension.

Contemporary agricultural extension was first realised following the start of the Renaissance period in 14th century Europe. Between 1300 and 1700, European society evolved from a feudal system to nation states. Accompanying this age of exploration and expansion was the philosophy of ‘new-learning’ which encompassed the novel and rational inquiry of many aspects of society, including agriculture (Jones and Garforth, 1997).

Dissemination of the principles of new-learning was facilitated by the invention and commercialization of the printing press. This allowed a rapid increase in the scope of agricultural extension, both geographically and across a number of languages. The true impact of printed forms of extension was particularly evident by the 16th century, especially in Britain, through works such as Thomas Tusser’s ‘Five Hundred Points of Good Husbandry’, first published in 1557. This compendium was particularly noteworthy as it divided the agricultural year into months and communicated advice in a simplified form understandable to illiterate members of the Tudor farming community (i.e. through the use of rhyming couplets). This was one of the earliest examples where agricultural scientific discovery was presented in a form understandable to its target audience.

However, subsequent to the increased delivery of printed publications of agricultural information, a separation began to develop between those delivering agricultural extension (off-farm extension agents) and farmers. Early agricultural research, focusing on improvements in local rural communities, grew in scale in the 18th century and began to reside predominantly within the universities. The first university agricultural chair was inaugurated at Edinburgh University in 1790 and was followed by a number of similar posts in Great Britain and United States. In this environment of science and innovation, an internal process of critical review ensured continued improvement in the quality of research. However, the cost of a focus on peer acclaim reduced researcher commitment to conveying research results to farmers (referred to as the ‘ivory tower phenomenon’). The debate on how extension providers can best act as the link between scientific discovery and the farmer remains the core of current extension science (McCown *et al.*, 2002).

The number of agricultural periodical publications increased from two in 1523 to 26 by 1860. Jennings (2007) speculated that, by the turn of the 19th century, published information available to farmers would have exceeded the amount they were capable of absorbing. Therefore, an ‘alternative extension mechanism to published books’ was required. One example of this inadvertently developed as a result of an outbreak of potato blight in Ireland from 1845. The new British viceroy appointed to Ireland in 1847, the Earl of Clarendon, urged the Royal Agricultural Improvement Society of Ireland to appoint itinerant lecturers, later known as "Lord Clarendon's practical instructors in husbandry", to travel around the most distressed districts to inform and show small farmers, in simple terms, how to improve their cultivation and how to grow nutritious root crops other than potatoes.

The more recent evolution of agricultural extension from the more traditional linear transfer of technology or innovation directly to the farmer to the current ideology of building the capacity amongst farmers to operate as informed decision makers has been well reviewed (Coutts and Roberts, 2010; Rivera, 2001; Rivera, 1996).

In a working document for the Australian State Extension Leaders Network (SELN), Vanclay and Leach (2007) presented a simple summary of the paradigm shift in thinking around agricultural extension that has occurred in the previous five decades (Vanclay and Leach, 2007).

1960's and before: *Technology transfer*: Diffusion of innovation and transfer of technology were accepted models of extension. Scientists undertook research or developed a particular innovation and these were delivered to farmers via extension agents. This top-down method of information transfer was endorsed by the World Bank *Training and Visit* system and is considered paternalistic by modern standards.

1970's: *Farming Systems Research*: In response to an apparent failure in technology transfer to agricultural industries, farmer discussion groups informed researchers and extension agents of farmer priorities, including the need for research to be carried out in a farming context to specifically solve problems on-farm (Packham, 2010).

1980's: *Systems thinking*: Extension priorities became increasingly focused on landholder needs and solutions. During this phase, action learning and adult education principles were incorporated into agricultural extension programs (Frost, 2000).

1990's: *Pluralism*: With a growing literature on theories, methods, tools, providers and processes, agricultural extension was increasingly able to deliver outcomes while meeting the needs of a diverse range of clients. Agricultural extension supported social learning processes and participatory methodologies as a means to enable practice change.

2000+: *Capacity building and community engagement*: Public/private partnerships, public/private benefit, competitive neutrality and increased private sector service provision arose as a result of a shift away from state agencies acting as the primary provider of services. Capacity building extension was developed based on the following five principles:

1, support and facilitate farmer learning;

2, incorporate all significant parties involved in the outcome;

3, establish agreed goals with all significant parties;

4, ensure that the goals align with strategic organisations and funders; and

5, ensure that the extension remains adaptable (Macadam *et al.*, 2004).

Adapted from Vanclay & Leach (2007)

There have been two principle drivers of this paradigm shift. Firstly, the reduction of state and institution-led funding of agricultural extension has resulted in a greater reliance on industry or individual funding (i.e. decentralization of funding), leading to a greater scrutiny of the potential benefits of the programmes (Rivera, 1996). Secondly, and partially driven by the former, the progress in agricultural extension research ('extension theory') has led to capacity-building being regarded as the preferred model (Coutts and Roberts, 2010). This, in turn, has led to modification and revision of the methods used to conduct agricultural extension and a reduction in the level of manpower providing the extension (Appleman and Norell, 1981; Hutjens and Baltz, 2000).

As a result of the decentralisation of funding, the responsibility for providing agricultural extension tends to lie with levy boards, public cost-recovery and private contracts in developed countries with large, established primary agricultural industries. Conversely, in countries with smaller or subsistence industries, government and/or international funding is essential. As illustrated in Table 1.2, within a country the needs and funding arrangements for varying farm sizes differ, with mid- and large-sized farming operations requiring relatively more advanced technology and advice around farm management than smaller or subsistence operations (Chase *et al.*, 2006). Based on these principles, it is appropriate that the levy body of the New Zealand dairy industry (DairyNZ) is primarily responsible for providing extension to its stakeholders.

Table 1.2. Farmer needs and most likely provisions for extension arrangements stratified by suggestion of farm size

Farm size	Needs	Arrangements
Large	Higher tech	Levy boards; private contracts; public cost recovery extension
Mid	Higher tech/farm management/processing	Private contracts; public extension with eventual cost recovery
Small	Needs assessment/lower tech/farm management/ organizational skills	Public extension services; co-operatives; farmer associations
Subsistence	Needs assessment/low tech/organizational skills	Public extension services

Adapted from Rivera (1996)

1.2.2. *Current models of agricultural extension*

Black (2000) reviewed the spectrum of agricultural extension that has been offered to Australian farmers and described four strategies, three of which are illustrated in Table 1.3.

He contrasted the *top-down* transfer of technology with the *farmer-first* (or *bottom-up)* farmer-driven extension. As the complexity of agricultural extension increased, Black contended that the emphasis of extension should be placed on 'empowering people and groups to engage in the on-going processes of experimentation, learning and human development'. This was not to the exclusion of top-down technology transfer but rather to increase the level of capacity building of the end-user as the complexity of the subject increased. The review concluded that a single model of agricultural extension is unlikely to be sufficient and that all forms of extension, including one-on-

one advisory services, may be necessary in complex situations. Currently, most US agricultural-based extension programmes are based on the principles of services to farmers, farmer participation, adult learning and action learning (Frost, 2000).

Table 1.3: Agricultural extension models with examples categorised by Black (2000).

Extension model	Methods and media
(1) Technology transfer (or information access)	Events such as field days to demonstrate new farming technologies Meetings to present information to the farming community Print media, including rural newspapers, magazines, newsletters, books and leaflets Radio, television and videos Computer applications Information centres World Wide Web
(2) One-to-one (or information exchange)	One-to-one technical advisory services Farm management consultancy Diagnostic services Rural financial counselling Informal information exchange between farmers
(3) Formal or structured education or training	University courses Training modules in Property Management Planning programmes Other structured learning programmes such as *InCalf* One-off events based on adult learning principles

Adapted from Black 2000: Extension theory and practice: A review

1.2.3. *(1) Technology transfer (linear or 'top-down' model of extension')*

This traditional method of extension has been well debated (Black, 2000; Coutts and Roberts, 2010). The principal criticism of the top-down model is the assumption that the model engages 'participatory or early-adopter' farmers and as a result of that engagement, technology will diffuse through to other, less engaged farmers over time. Moreover, this model may enlarge the social, intellectual and material inequalities among farming communities (Black, 2000). This is an important consideration for extension agents when trying to achieve national targets. It would be sensible to assume that the 'early-adopter' farmer was most likely to manage already high- performing herds and, therefore, less able to lift herd-level performance in response to agricultural extension messages. Engaging farmers of the lower-performing herds would be a priority in this case. However, Jansen *et al.*, (2010a) found no significant correlation between farmer participatory category (in this case categorised as proactivists, do-it-yourselfers, wait-and see-ers and reclusive traditionalists) and herd performance in regard to BMSCC. This indicated that non-participatory farmers are not necessarily poorly informed or unwilling to adopt a change in management behaviour and, as a result, are not necessarily the poor performers. More proactive communication strategies were recommended to get engagement from these farmers.

Despite the criticisms, the top-down model is still employed in several forms in current agricultural extension, such as farmer field days (Table 1.3), with some historical success suggesting that for some innovations, this method remains effective.

Among the current top-down media are computer-based decision support systems (DSS). These are normally constructed from logic- or simulation- based algorithms designed to provide the most cost-effective or profitable decision around resource management (Kerr and Winklhofer, 2006; McCown *et al.*, 2002; Smith, 1989). However, the duration or extent of the impact of DSS have not been widely evaluated (Hochman and Carberry, 2011). For example, DairyNZ have developed a number of decision support system tools which have been made freely available via their website (e.g. InCalf Fertility Focus Report for evaluating reproductive performance and support of decision-making), but no published evaluation of their effect has been undertaken.

1.2.4. *(2) One to one (or information exchange)*

One to one extension from central government or university bodies has declined, with this model considered a “private good” and, consequently, the cost of agricultural extension via this method is typically borne by the recipient (Black, 2000). However, private advisory services have expanded (Hall *et al.*, 1999; Wilson, 2011) causing concern among extension providers and industry that the message of these advisory services may not always be consistent or even correct.

Anecdotal experience from the veterinary industry is that this method is preferred by farmers, with evidence that the veterinary practitioner is the most trusted adviser on cattle health and reproduction (Mee, 2007). Cattle health extension commonly uses this model (Bell *et al.*, 2003; Green *et al.*, 2007) and a number of veterinary consultants have used this approach (e.g. McKay, 2000).

1.2.5. *(3) Formal or structured education or training*

Formal or structured extension has received a mixed response from farmer participants and extension agents (Coudel *et al.*, 2011; Johnson *et al.*, 1996). A number of contributing reasons have been put forward for the reluctance for farmers to undertake formal training (Black, 2000) summarising (Johnson *et al.*, 1996):

1. Lack of time (especially if additional labour is required);
2. Questioning the relevance of tertiary courses to farming;
3. Belief that the competencies required for farming are essentially practical;
4. A lack of awareness of courses available;
5. Lack of confidence in ability to undertake the study; and/or
6. Prevailing attitude in some rural communities to the respective roles of men and women.

In developing a structured extension programme, these barriers need to be considered. Despite this resistance, there is anecdotal evidence that participation in structured extension programmes may increase farm profit although these studies did not use robust methods to attribute the profit to the programme (Johnson *et al.*, 1996; Johnson *et al.*, 2003; Kilpatrick, 1997; Lloyd *et al.*, 2009). Farmer preferences for the content, approach and delivery of these programmes were discussed by Bamberry (2006) following extensive farmer interviews. The report found that formal programme development needs to ensure:

1. The 'practicality and applicability of programmes to farmers' individual situations and local conditions';

2. the 'availability of appropriate information about the content of programme and teaching approaches used'; and

3. that delivery modes and assessment strategies making allowances for the seasonality of farm work and farm commitments.

However, no significant relationship was found between preference for formal structured extension and the level of farmer education.

The InCalf reproductive extension programme evaluated in this thesis utilises all three of these models of extension, either individually or together, depending on its level of adoption.

1.2.6. *How it works*

[a] Knowledge, Attitudes, Skills and/or Aspirations

Figure 1.4. Simplified schematic of the proposed pathway to effecting change in end-result

The primary intention of agricultural extension is to improve one or more aspects of farm performance (an ‘end result’). In turn, a change in performance usually requires one or more forms of on-farm practice change (Figure 1.4). Therefore, extension programmes generally aim to introduce a new behaviour or to modify a current one, such as choosing the most appropriate cow shed for a feed system using online decision support software (Kerr and Winklhofer, 2006) or improving herd reproductive performance through facilitated and structured meetings (Britton *et al.*, 2003). As a consequence, extension theory borrows heavily from behaviour theory. Behavioural approaches in agricultural extension seek to:

1. understand the behaviour of individual decision maker;

2. focus on psychological constructs, such as attitudes, values and goals; and

3. employ largely quantitative methodologies for investigating these psychological constructs (Burton, 2004).

Early behaviour theory referenced work by Simon (1956) who proposed that people do not necessarily base decision-making solely on economic factors, but instead could use ‘social, intrinsic and/or expressive goals’ (the ‘satisficing concept’). Similarly, a classification of farmer goals and values by Gasson (1973) included ‘non-economic factors’. This was pertinent to the development of agricultural extension since farmer attitude was considered intrinsic to both the uptake of the programme and the likelihood that change would be effected as a result. Consequently, it became necessary to provide more than just economic reasons to encourage uptake of recommendations within agricultural extension programs. However, Valeeva *et al.* (2007) identified that a penalty system (e.g. financial penalty for a high BMSCC) provided better motivation for farmers than a premium system (e.g. financial reward for a low BMSCC). Despite this, a third group was also identified that were most motivated by farm efficiency and pride.

Behavioural theory proposes that intention to change is the key determinant of behavioural change (Coudel *et al.*, 2011). A meta-analysis of 47 randomised, controlled experimental studies in public health found that a medium to large intention to change was required in order for there to be a subsequent change in behaviour (Webb and Sheeran, 2006). The theory of reasoned action measures the effect of attitude on behaviour. It employs intention as an intermediate step to allow a measured attitude to be transferred to a behaviour (Fishbein, 1975).

A criticism of the theory of reasoned action was the emphasis on attitude as the main driver for behaviour. Consequently, the theory was revised to include subjective or perceived social norms as a way of quantifying farmers beliefs of 'whether significant others believe that a farmer should engage in the behaviour' (i.e. that decision making by farmers is not independent). For example, a farmer's decision to reduce the use of pharmaceutical induction of calving in their herd could be influenced by their perception of other's opinions or actions (e.g. family, other farmers or advisors).

A second revision of the theory of reasoned action was the addition of 'perceived behavioural control' which measures the extent to which farmers believe they are able to control the outcome of the behaviour or behavioural change. Ajzen and Madden, (1986) suggested that 'the more that attainment of a behavioural goal is viewed as being under volitional control, the stronger the person's intention to try'. For example, contracts between sharemilkers and farm owners in New Zealand often allot annual feed budgeting as the responsibility of the land owner. This provision removes the ability of the sharemilker to control some management factors, such as cow body condition. These revisions superseded the theory of reasoned action as the current theory of planned behaviour *(*Ajzen, 1991b).

Numerous studies have examined the attitude of dairy farmers toward improving mastitis and reproductive management (Bigras-Poulin *et al.*, 1985a; Bigras-Poulin *et al.*, 1985b; Dohoo *et al.*, 1984; Garforth *et al.*, 2006; Jansen *et al.*, 2009; Rehman *et al.*, 2007; Valeeva *et al.*, 2007; Wenz *et al.*, 2007). Bigras-Poulin *et al* (1985a, b) were one of the earliest to report that farmer's attitudes and socio-demographic profile explained similar or greater variation in performance than farm management practices alone, although no specific attitude was implicated. In agreement with these findings, Jansen *et al* (2009) reported that management practices accounted for less variation in BMSCC than attitude alone. Rehman *et al.*, (2007) also identified that not accounting for farmer's personal expertise with their own herd was a barrier to the uptake of extension.

Bigras-Poulin *et al* (1985a, b) promoted the idea that the motivation of the farmer has two levels; firstly, the adoption of a management change is influenced by farmer discretion and, secondly, that any benefit associated with the change is associated with the perceived benefit by the farmer. This second level is a measure of the quality with which the change is enforced or undertaken. Both of these levels are linked to the attitude of the farmer and, so, documenting and understanding farmer attitude and motivation is important when understanding between-farm variation and increasing the likelihood of farmer uptake of extension messages. To date, there has been limited published description of current dairy farmer attitudes towards reproductive performance in New Zealand (Burke *et al.* 2008). Consequently, this has been reported in Chapter 2.

Farming is a complex, organic process, involving social and cultural activities (Vanclay, 2004) and although the measurement of farmer attitude is prone to subjective inference, consistent themes have appeared throughout the relevant literature. In a novel summary of agricultural extension, Vanclay (2004) described 27 principles of enabling change, some of which were discussed above, based on his personal experiences as an extension specialist. As the principles were written relating to natural resource management, only those believed most pertinent to this review are listed next:

Farming is a socio-cultural practice: Farming is a vocation as opposed to a set of technical principles with an identity deeper than other vocations and, as such, it is governed by social principles.

Farmers are not all the same: It might be more appropriate to group farmers in farming styles (i.e. priorities, constraints and attitudes) rather than traditional demographic or socio-demographic factors.

Adoption is a socio-cultural process: Adoption is not a process of passive adoption from a scientific origin. Most adoption occurs when the technology has become normalised through discussion and acceptance as good management.

Profit is not the main driving force of farmers: Repeatedly, profit has not been found to be a driving force for farm decision-making.

'Doing the right thing' is a strong motivator: Although the 'right thing to do' in terms of farm management is difficult to define and often individual, it is responsible for greater adoption of technology than profit.

Farmers construct their knowledge: Scientific knowledge is evaluated alongside farmer experience and does not automatically have credibility or legitimacy.

Effective extension requires more than the transfer of technology, it requires an understanding of the world views of farmers: Understanding the needs of farmers and farming communities is imperative if extension is going to be adopted.

Farmers have legitimate reasons for non-adoption: Possible reasons for a farmer's reluctance to adopt a technology are discussed above.

The best method of extension is multiple methods: In light of the complex socio-cultural basis of farming, multiple methods are required to deliver and reinforce the extension message.

Group extension is not a panacea: Although group extension has virtues, some on-farm issues require one-to-one extension to assist with on-farm issues. Furthermore, group facilitators require credibility and this is often gained through on-farm advice.

Extension is likely to have only a small impact: Realistic expectations about the effect of an extension programme need to be held.

1.3. Evaluation of the effect of agricultural extension

As agricultural industries evolve over time, it can be difficult to keep the goals of agricultural extension current, particularly as the goals are often broad and sometimes multiple (Hutjens and Baltz, 2000). Increasingly, the debate about the value of extension has been orientated around the requirements of stakeholders and policy makers who wish to assess their relative investment in agricultural extension (Chase *et al.*, 2006; Murray, 2000). To date, evaluation of the success or otherwise of agricultural extension has principally used evaluation or outcome theory developed by political and health professionals to evaluate policy. For example, Penna and Phillips (2005) described eight models used to evaluate policy and programmes that fell into three main categories:

1. programme planning and management models;
2. programme and resource alignment; and
3. programme reporting.

Of these models, Targeting Outcomes of Programmes (TOP), based on Bennett's Hierarchy for developing objectives (Bennett, 1975), was established as a flexible and useful framework to evaluate agricultural extension (Cameron and Chamala, 2004; Farrell and McDonagh, 2012). Bennett's Hierarchy will be outlined in detail in order to provide a logical framework for the review of published evaluations of agricultural extension.

Bennett's Hierarchy

As outlined in Figure 1.5, Bennett's Hierarchy consists of seven sequential criteria, outlining the recommended steps to plan, implement and evaluate agricultural extension programmes. At each level of the Hierarchy, targets are set and assessed using appropriate study design. Modifications were made to the Hierarchy by Bennett and Rockwell in 1995 (Bennett and Rockwell, 1995) by adding a continuum that links programme evaluation and programme development. This revision suggested that evaluation should be considered in the design phase of a programme, not as a post-hoc procedure.

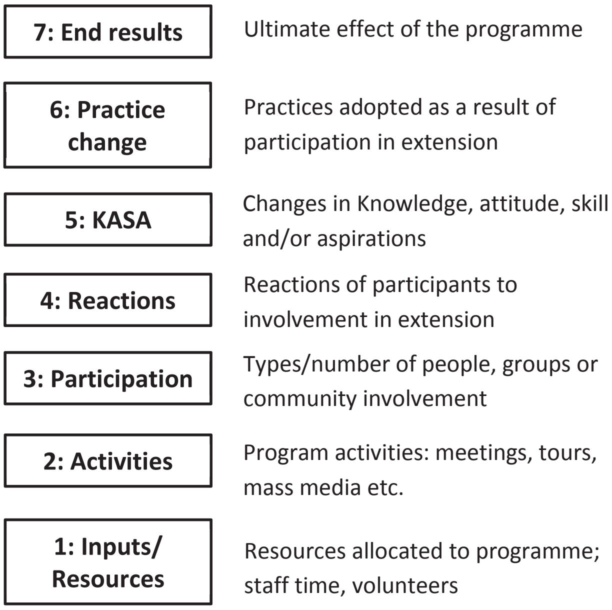

Figure 1.5: Bennett's Hierarchy (Bennett, 1975)

The Hierarchy is accompanied by three guidelines

1. *The evidence of an extension programme's impact becomes stronger as the hierarchy is ascended;*
2. *The difficulty and cost of obtaining evidence of accomplishments increases as the hierarchy is ascended; and*
3. *Robust ('hard') evidence is usually ideal but is more expensive and difficult to obtain.*

Ideally, extension should be evaluated using the highest level, the 'end-result' (e.g. herd-level reproductive performance). However, as discussed earlier in this review, information on changes in farmer knowledge, attitudes, skills and aspirations (i.e. Level five) and practice change (i.e. Level six) as a result of the programme provide is essential to determine how the end result was achieved.

A positive association has been proposed between the duration of the extension's effect (i.e. short, intermediate, or long-term effect) and the seven steps of the Hierarchy (Radhakrishna and Bowen, 2010). For example, the long-term effects of a programme are normally only detectable at the higher levels of the Hierarchy. Simple measures could be used to assess short-term outcomes (e.g. attendance register at farm open days), but to assess farmer behaviour or practice change; on-farm measures, such as heifer live weights, may be required. End-result measures are often subject to a time lag following the extension event. Consequently, the possibility of one or more alternative influence(s) or bias(es) being responsible for a false positive improvement in the end result increases. This reinforces the need for a robust measure of the end-result and a longitudinal study design with complex or repeated data collection, normally incurring a relatively high level of resource, skill and cost.

In social science literature, personal opinion or perception of programme success (level of effect), rather than robust scientific evidence are commonplace. While the former are valuable if the providers have an informed view, robust quantitative data provide relatively more precise and defensible evidence of the likely effect of agricultural extension on the end-result.

Typically, Levels 1 to 4 of the Hierarchy are used to evaluate the process of the agricultural extension programme (i.e. process evaluation), whereas Levels 5 to 7 evaluate the impact of the programme (i.e. outcome/impact evaluation).

1.3.1. *Levels 1 and 2: Inputs and Activities*

Allocation of resources for extension programmes and the activities utilised are components of the extension programme. Evaluation of these would normally require observational or case studies and are not examined here.

1.3.2. *Level 3: People involvement*

Level 3 is of interest in an evaluation of the effect of agricultural extension as program uptake is commonly voluntary. A significant proportion of published literature on agricultural extension is focused on this subject (Kerr and Winklhofer, 2006; McCown *et al.*, 2002; Pannell *et al.*, 2006). Although Level 3 is strictly process evaluation, it is discussed within this literature review in association with Levels 5 to 7, which focus on outcome evaluation, due to its relevance.

Within Level 3, the success or otherwise of an agricultural extension program is specifically assessed based on the number and/or types of people that were involved (Bennett, 1975). For example, a decision support software application might be regarded as successful at this Level if it was trialled by 20% of dairy farmers in a region, whereas a focus farm open day may be considered unsuccessful if less than 50 farmers attended.

Although collection of reliable data for this Level is typically relatively simple and timely, reporting is often qualitative, with quantitative results rarely presented. Published studies evaluating farmer involvement in agricultural extension predominately focus on theories to improve programme attendance including incorporating the perceptions of extension experts and questionnaire-derived information on farmer beliefs and attitudes. An example of the former was the low trialling (<5%) of a decision support extension system in the North Australian dairy industry that was reportedly due, based on the personal experience of the project manager, to the recent deregulation by milk processors and the subsequent change in requirements (Kerr and Winklhofer, 2006). In comparison, a more robust cross-sectional study design was used to analyse farmer uptake of an Australian farm business management extension programme using face to face or phone interviews with farmers and extension agents (Murray, 2000). As a result, the authors were able to report a simple univariate analysis of socio-demographic variables to evaluate reasons for and against farmer attendance at the extension programme.

Work from Scandinavia, utilising relatively complex Q methodology (Dziopa and Ahern, 2011), evaluated how dairy farmers perceived the value of involvement in health management programmes (Kristensen and Enevoldsen, 2008). This study challenged the belief that farmer's motivation was predominantly financial as farmers identified teamwork, animal welfare and knowledge dissemination as their highest priorities. Conversely, herd health providers/extension agents reportedly believed that production and financial gain were the key drivers of the same farmers. A review of 14 case studies of national and regional decision support systems in Australia, suggested that if farmers perceived that extension tools were bypassing their own decision-making processes, then there was considerable resistance to attendance. Conversely, where the extension tool was perceived to help modify farmer decision-making it was found to have a relatively higher uptake (McCown *et al.*, 2002).

1.3.3. *Level 4: Reactions*

Reactions which may result in a farmer's interest in the extension or the subject have not been examined. This Level would be examined using observational or questionnaire data ideally at the close or in the period immediately following the extension exposure. Internal feedback questionnaires built into formal structured extension meetings are collected in some programmes (including InCalf) and used by coordinators to improve provision yet unpublished. Reactions to extension cannot be tested using a controlled study design.

1.3.4. *Level 5: Change in Knowledge, Attitudes, Skills and/or Aspirations (KASA)*

In section 1.2.6 this review discusses examples of current farmer attitudes in regards to on-farm performance (e.g. mastitis and reproduction). Level five evaluates the change in the direction and durability of the knowledge, attitudes, skills and/or aspirations (intentions) of the participants as a result of an extension programme. Furthermore, the intensity of the change in attitude and the height of the aspiration can be measured (Bennett, 1975).

Knowledge, attitude and aspirations require questionnaire data from participants (Radhakrishna and Rhemilyn, 2009). A robust framework to evaluate this is the theory of planned behaviour or the earlier theory of reasoned action (Ajzen, 1991b). Examples in the literature use either cross-sectional post-exposure or pre- and post-exposure interviews to measure change in attitude. While these are valid methods, attributing causality is normally inappropriate since causes of change in attitude other than through exposure cannot be excluded. The most valid method of attributing the correct effect of the extension would require a representative control group for comparison (i.e. a randomised controlled study design). Currently, there is no published work using a randomised controlled design to evaluate knowledge, attitudes, skills or aspirations in agricultural extension or similar topics.

Rehman *et al.*, (2007) used the theory of reasoned action for a 500 postal survey questionnaires in a cross-sectional study to evaluate attitudes and subjective norms that affected the intention to undertake nationally recommended oestrus detection practice. This study design allowed the authors to identify significant drivers for uptake as cost effectiveness ($p \leq 0.001$), improved heat detection rates ($p \leq 0.001$), improved conception rates ($p \leq 0.05$) and effectiveness on silent heats ($p \leq 0.05$) as influential drivers for oestrus detection. It also found a higher correlation between social norms (or pressures) and intention than with attitudes and intentions. The study used and achieved a 29% response rate. While the sample size (137) was moderately high, the selection bias inherent in the mail response reduces the external validity of these results. Jansen *et al.*, (2010b) used a pre- and post-exposure postal interviews to quantify the effect of a national mastitis extension programme on change in attitudes, knowledge and behaviours of 204 Dutch dairy farmers that undertook the study. This study found a significant effect of the programme on a number of attitudes and knowledge, however, the study recognises that, without a control group, the change cannot be fully attributed to the exposure. By stratifying responses by BMSCC (an end result measure) the confounding effect of pre-exposure BMSCC could be evaluated against the change in attitude and knowledge. Although an overall significant effect of a national mastitis programme on farmer attitudes, knowledge and behaviours was reported, a change in attitude applied to all farmers regardless of preceding BMSCC.

Varner *et al.*, (1989) evaluated retention of knowledge immediately following a two or three day top-down herd reproduction extension for dairy farmers in Maryland USA. A random sample of attendees submitted a quiz before and at the end of a two or three day extension programme. The study found a significant improvement in knowledge after the course. It continued by measuring eight end-results (e.g. days open, services per conception) for the subsequent two years to compare outcomes to prior levels and evaluate the duration of effect, concluding that the effect of this extension was transitory.

1.3.5. *Level 6: Practice Change*

Level 6 quantifies changes in these practices, technology and/or social structure as a result of the extension (Bennett, 1975). Data at this level could be collected through either farmer self-reporting, measured through objective on-farm observations or derived from farm records. Obsequiousness bias introduced through self-reporting can make quantifying this problematic. Open and semi-structured interviews are preferable for reliable data collection but require experienced researchers (Cameron and Chamala, 2004; Nettle *et al.*, 2010).

A demonstration project of dairy extension was undertaken in the US where 30 herds participated in a multidisciplinary extension programme (Cassel *et al.*, 1994; Peters *et al.*, 1994a; Peters *et al.*, 1994b). The effect of the extension on management practices was analysed but discussed as being problematical. Traditional evaluation has treated management practice as a dichotomous variable simply describing whether a practice is undertaken without considering the intensity or commitment to the activity (Bigras-Poulin *et al.*, 1985b; Cowen *et al.*, 1989). Interestingly, the US study identified the largest benefit of the extension programme was in herds ranked lowest in terms of reproductive performance and where the greatest room for improvement was identified. Other studies evaluating practice change also did so in conjunction with an end-result (Green *et al.*, 2007; Cameron and Chamala, 2004) thereby confirming the effect of extension through practice change.

A Dutch mastitis study investigated associations between practice change and management styles on the incidence of herd-level BMSCC (Barkema *et al.*, 1998, 1999a; Barkema *et al.*, 1999b) and employed a novel approach through stratification of 291 Dutch dairy herds based on low, mid or high BMSCC and farmer description of their management style as either ‘clean and accurate’ or ‘quick and dirty’. A strong correlation between low BMSCC and clean and accurate (precise) management style was reported. It was suggested by the authors that extension agents need to take a farmer’s management style (i.e. ‘clean and accurate’ or ‘quick and dirty’) into account when offering expert advice on mastitis.

1.3.6. *Level 7: End Result*

End-result criteria are programme objectives and are assumed to be the product of the practice changes (Bennett, 1975). Definitive evaluation of the effect of extension requires that the end-results are evaluated. To do this, it is normally necessary to set targets for end-results.

Very few studies have examined the effect of agricultural extension programmes on the end result using robust study design (Green *et al.*, 2007). The most rigorous method of determining the effect of intervention is the randomised controlled study (RCT). Sir Austin Bradford-Hill introduced this method to British medicine in the 1940's, to test the efficacy of pertussis vaccine. Subsequently the RCT has since become the foundation for evidence based medicine (Lavori and Kelsey, 2002; Stolberg *et al.*, 2004). Dohoo *et al.* (2009) discuss the key features of RCTs and recognises that the size, scope and expense are major limiting factors in their application. However, RCT remains the most efficient way to control potential confounders and reduce selection along with some measurement biases.

Green *et al.* (2007) explored the outcomes of a novel mastitis extension programme on 52 British dairy herds in 2004. This currently appears to be one of only two truly RCTs used to assess a western agricultural extension programme in publication. Herds with ≥35% cases of clinical mastitis cases in the preceding 12 months were selected from the National Milk Record database and invited to participate. Within three regions (north, south east and south west England and Wales) herds were ranked and paired on closest mean annual BMSCC. Within these pairs, herds were randomly allocated to receive treatments or act as a control group. Treatment in this case involved a visit by one of two specialist veterinarians to implement a herd specific mastitis control plan based on current and established mastitis research and a follow up visit during the same year. A 22% decrease in new cases on mastitis (p=0.01) and a 20% decrease in total mastitis cases (p=0.04) was found in the treatment group when compared to the control one year after the start of the extension. Researchers with the trial conducted pre- and post- treatment interviews to establish compliance with the plan and found an encouraging trend whereby greater compliance to the mastitis control plan recommendations correlated with a greater decrease in both new and total clinical mastitis events.

The treatment in this study was not comprised of novel recommendations on better mastitis management; nevertheless, it was undertaken by two national mastitis experts. The reproducibility of the programme by less experienced practitioners may therefore be less effective. Despite this, the results are encouraging for one on one extension programmes. The study design allowed the effect of intervention on the end-result to be quantified. In this case, it would be appropriate to assume that this was due to practice change recommendations. A further step for future studies would be to explore the change in knowledge, attitudes, skills and/or aspirations of the participants. If participants were followed for longer, changes at this level may be more important to sustain the longevity of effect. Clinical mastitis prevalence can be altered relatively quickly in non-seasonal herds as compared with altering reproductive performance in seasonal herds. A greater time lag is found between each practice change and seasonal end-result measures in non-seasonal systems. It is feasible that without a lasting change in knowledge, attitudes, skills and/or aspirations, the longevity of the effect of the mastitis control plan may be reduced.

Bell *et al.* (2009) undertook the second RCT evaluating an extension programme (lameness control programme) among heifer mobs in 60 British herds. The extension used hazard and critical control (HaCCP) evaluation of putative risk factors for lameness in heifers and recommendations for farmers were farm-specific and given by trained, regional veterinarians. Herds in this study were nominated by regional veterinary practices for having anecdotally high prevalence of lameness and were selected to represent three different calving strategies for heifer groups. This study used a preliminary year to obtain baseline measures before intervention since accurate measures of the prevalence of lameness among heifers was unavailable (unlike BMSCC for example). The effect of extension on the change in risk factors between year 0 (baseline) and year 2 of the study was evaluated and no significant effect of the extension was identified. However, Vickers (2001) suggests that change from baseline measures only have acceptable power when the correlation between baseline and post-treatment scores is high and given that seasonal and between herd variablility may effect this, reanalysing these results using an ANCOVA may be appropriate to find significant effects. The study also explored compliance to the extension in both veterinarians and among the farmers and also veterinarian-by-farmer interactions. A low level of compliance was identified in both and the interaction term was significantly associated with a change in heifer gait unsoundness ($r^2 = -0.498$, $p=0.007$). The study however used a retrospective analysis of risk factors and expert observation to identify critical control points for future extension.

A similar study undertaken by the same researchers used a large (non-random) controlled study to examine the effect of a one-on-one extension programme on prevalence of lameness in dairy herds (Main *et al.*, 2012). The study enrolled 227 herds from client bases of four dairy companies and allocated to treatment and control based on region. Regional allocation reduces the dilution of effect from random allocation within each region and therefore reduces the complexity of the study administration as a result, however, this is not strictly random allocation and geographical bias was noted. The extension support was undertaken for the three years of the study. During the first year, recommendations were given following a specialist consultation, and in remaining years, the treatment consisted of facilitated sessions where the farmer determined their own actions for the forthcoming year. These were not undertaken by veterinary specialists. This study also benchmarked knowledge, attitudes, skills and/or aspirations and current practices at the beginning of the study providing valuable data for the expansion of the extension programme (Barker *et al.*, 2010; Leach *et al.*, 2010a, b).

1.4. Conclusions

This review has described the New Zealand dairy industry and the apparent decline in reproductive performance. It briefly reviewed the methods and results employed by both the New Zealand and Australian herd reproduction studies and reinforced the need for a current and accurate benchmark of national reproductive performance.

The evolution and more recent transition of agricultural extension to recognising farmer-centric, capacity-building frameworks have been discussed. Within this current framework, three extension models are employed; top-down technology transfer, one-to-one consultation and formal structured or facilitated group meetings. Each one of the models is effective at one or more levels; however, when used in combination, extension research suggests that it results in greater effectiveness.

Finally, a selection of study designs was proposed within a hierarchy of levels in which extension can operate. Ultimately, the role of extension needs to be evaluated at the end-result level. However, evaluating the impact of extension at higher levels incurs greater time, resource and cost.

This review prefaces the evolution and process of the InCalf herd reproduction extension programme. The InCalf programme engages farmers using all three extension models: Top-down technology transfer is provided through a technical manual (The InCalf book for dairy farmers) and decision support systems (InCalf Fertility Focus Report), one-to one consultation was available on request with trained extension advisors and structured facilitated regional group meetings were employed to adhere closely to the ‘plan-do-review’ process integral to the InCalf programme. Based on this review of current extension models, there is a strong case to predict success of the InCalf programme on the grounds that it employs a range of methods to engage participants, but this requires formal evaluation.

In order to quantify the effect of InCalf programme on the end-result (reproductive performance) a RCT design is necessary. However, this needs to be geographically diverse (multiple regions) and needs to be longitudinal (multi-year) in order to correctly identify and attribute the effect of the extension. There are limited international examples of such studies.

Furthermore, Pannell *et al.* (2006) contends that the end-result may not be sufficient to quantify the effect of capacity-building extension and therefore the study design should be suitable to detect practice change (and even knowledge, attitudes, skills and aspirations) from lower levels of the hierarchy of effect. This presents additional benefits since that herd reproductive performance is multifactorial, so identifying the strength and weaknesses of the extension on differing management practices presents opportunities for improvement to the extension programme.

1.5. Objectives of the study

The primary aims of this thesis were to benchmark current reproductive performance and farmer attitude toward herd reproduction in their herd and quantify the effect of farmer participation in the InCalf extension programme in the form of the InCalf Farmer Action Group (formal farmer meeting programme) on the reproductive performance of a representative sample of herds from four diverse dairy regions of New Zealand following the launch of the programme.

These aims were achieved by undertaking of a large-scale RCT within each of four regions of New Zealand during the 2009/2010 and 2010/2011 seasons.

To understand the impact an extension programme could have, two cross sectional studies of farmer attitudes, priorities, perceived constraints and current herd level reproductive performance were undertaken.

The key objectives of the study were:

> *Objective 1:* To examine the attitudes, priorities, and constraints pertaining to herd reproductive management perceived by farmers managing seasonal-calving, pasture-based dairy herds in our regions of New Zealand, and to explore how these varied with demographic and biophysical factors (presented in Chapter 2).
>
> *Objective 2:* To describe the reproductive performance in a selection of New Zealand dairy herds in 2009/10 and 2010/11. A secondary objective was to explore associations between the herd-level reproductive outcomes and a number of biophysical and socio-demographic herd-level variables (presented in Chapter 3).
>
> *Objective 3:* To quantify the effect of dairy farmers participation in the InCalf Farmer Action Group on six week in-calf rate, using a randomised controlled study design. Additionally potential biophysical and socio-demographic confounding factors should be examined and the potential effect of being involved in an actively monitored control group (presented in Chapter 4).

Objective 4: Comprised of three sub-objectives (presented in chapter 5):

a. To compare herd performance for six key management factors that affect reproductive performance between treatment and control groups;

b. To describe the proportions of farmers that intended to change management behaviour(s) affecting each key management factor after participation in the InCalf Farmer Action Group ('treatment');

c. Of farmers that intended to change their management behaviour(s), to describe the proportions that reported successfully undertaking these 'actions',

Objective 5: To establish a well validated dataset for the reproductive performance of the New Zealand Dairy Herd during 2009/10 and 2010/11 for continuing and subsequent analyses

CHAPTER 2

Reproductive management of dairy herds in New Zealand: Attitudes, priorities and constraints perceived by farmers managing seasonal-calving, pasture-based herds in four regions

TS Brownlie, AM Weir, I Tarbotton, JM Morton, C Heuer and S McDougall

2.1. Abstract

AIMS: To examine attitudes, priorities, and constraints pertaining to herd reproductive management perceived by farmers managing seasonal-calving, pasture-based dairy herds in four regions of New Zealand; and to explore how these varied with demographic and biophysical factors.

METHODS: Key decision makers (KDM) on 133 dairy herds in four dairy regions (Waikato, Taranaki, and north and south Canterbury) were interviewed between May and July 2009. They were asked to provide demographic and biophysical data about the farm and to rate their attitude in relation to their own personality traits, management issues and priorities, and likely constraints affecting reproductive performance in their herds. Associations between demographic factors and attitudes, priorities and constraints were analysed using univariate and multivariable proportional-odds regression models.

RESULTS: Farms in the regions studied in the South Island were larger, had larger herds and more staff than farms in the regions studied in the North Island. The farms in the South Island were more likely to be owned by a corporation, managed by younger people or people who had more education, and the herds were more likely to be fed a higher percentage of supplementary feed. The majority of KDM rated the current genetics, milksolids performance and reproductive performance of their herds as high or very high, and >70% believed that the reproductive performance had remained the same or improved over the preceding 3 years. Despite this, improving reproductive performance was the most highly rated priority for the next 3 years. The constraints considered most likely to have affected reproductive performance in the last 2 years

were anoestrous cows, protracted calving periods, and low body condition scores; those considered least likely were artificial breeding and heat detection. Of the 40 variables examined related to attitudes, priorities and likely constraints, there were significant differences between region for 10/40, and with age and occupation of the KDM for 24/40 and 5/40, respectively ($p<0.05$).

CONCLUSIONS: The majority of KDM reported the current reproductive performance of their herds to be high or very high, yet rated improving reproductive performance as a very high priority for the next 3 years. Mismatch between perceived and actual performance may result in reduced uptake of extension programmes designed to improve performance, and accurate benchmarking may help increase uptake and engagement. Further work is needed to determine whether the attitudes and perceptions about performance of farmers affect the likelihood of changes in their management behaviour which translate to measurable change in the actual reproductive performance of their herds. The variation in attitude, priorities and perceived constraints among age groups and region indicates that design of extension programmes may need to vary with these demographics.

2.2. Introduction

Reproductive performance of dairy herds in New Zealand has been decreasing over the last 15 years (Harris *et al.* 2006). This is similar to trends in other countries (Butler 2000; Royal *et al.* 2000; Lucy 2001). In New Zealand's dairy system, 90% of herds operate a spring-calving, seasonal-supply, pasture-based system, that presents unique challenges to the manager of the operation (Verkerk 2003). A pivotal requirement of this system is to achieve a compact calving pattern of 8–12 weeks, to align nutritional demands of cows with patterns of pasture growth. In an analysis of the national dairy database, Harris *et al.* (2006) identified a 10% decline in the proportion of cows re-calving within the first 42 days of the subsequent seasonal calving period, from 1990 to 2004. However, there is variation in performance among herds; in another national study, in the top quartile of herds, the mean 6-week in-calf rate was 78% (percentage of cows pregnant within the first 6 weeks of mating), mean 3-week submission rate was 90%, and mean conception rate to first artificial breeding[a] was 62%, compared with 57%, 67% and 43% for these variables, respectively, for the bottom quartile of herds (Xu and Burton 2003). In 2006, a national needs-analysis survey of 200 dairy farmers in New Zealand showed that 58% were only 'slightly satisfied' or 'not at all satisfied'

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[a] Artificial breeding is a term unique to New Zealand to describe artificial insemination

with the level of reproductive performance in their herds, but 57% acknowledged that they “had a lot of control over the reproductive performance of their herd” (Burke *et al.* 2008).

In the dairy system in New Zealand, the key decision maker (KDM) on the farm may be an owner-occupier, a sharemilker, a farm manager, or the manager of an equity partnership. The KDM has a large influence on farm management and hence on herd reproductive performance. Associations between a farmer’s attitudes, management practices and the herd’s reproductive performance were demonstrated >25 years ago (Bigras-Poulin *et al.* 1985ab). Subsequent work in the United States of America (Cowen *et al.* 1989ab) described reproductive performance, and identified univariate associations between it and management factors. However, that study focussed on perceived constraints and did not explore other attitudes. More recent work from Scandinavia used more complex Q-methodology to evaluate how dairy farmers perceived the value of being involved in herd health management programmes that included reproductive management (Kristensen and Enevoldsen 2008). That study demonstrated that teamwork, animal welfare, and dissemination of knowledge were the highest priorities for farmers. In contrast, providers of the herd health programme in that study perceived that production and financial gain were the drivers for the farmers. The farm manager influences farm management by choosing which management protocols to adopt and the rigour with which they are implemented; both the adoption and rigour of implementation of a particular protocol are more likely if the manager perceives a clear benefit (Bigras-Poulin *et al.* 1985ab). Understanding the attitudes and motivation of farmers is important when designing and implementing extension programmes and activities aimed at helping them improve their farm’s performance (Paine 1993). Decision making on-farm is almost always multifactorial and complex, and the process for making these decisions can be over-simplified unless the drivers are fully understood (Nettle *et al.* 2010; Kristensen and Jakobsen 2011).

No work has been published to date on attitudes of KDM managing dairy herds in New Zealand pertaining to the reproductive management or performance of their herds. This study aimed to examine attitudes, priorities and constraints pertaining to herd reproductive management perceived by KDM managing seasonal-calving, pasture-based dairy herds in four regions of New Zealand, and to explore how these varied with demographic and biophysical factors. The overarching aim was to identify predictors of attitude potentially important when designing and implementing extension programmes to influence the behaviour of KDM.

2.3. Materials and methods

2.3.1. *Overview of the study*

This study was the first of a series of studies involving herds from four regions across New Zealand, collectively called the National Herd Fertility Study. The four regions were chosen to represent a diverse cross section of the dairy industry in New Zealand, both geographically and demographically. The National Herd Fertility Study was a herd-level randomised controlled trial, with dairy herds from four dairying regions of New Zealand systematically allocated to one of three treatment groups, *viz* one group was offered a reproductive extension programme and subject to on-farm monitoring, a similar-sized control group was not provided with the reproductive extension programme but was subjected to the same on-farm monitoring, and in a second control group neither the reproductive extension programme nor on-farm monitoring was undertaken. Farms in the first two of these three groups were enrolled in the current study, and results of baseline interviews conducted with the KDM identified on each of these farms are reported.

2.3.2. *Enrolment process*

Herds were selected from the client base of four veterinary practices based in the Waikato and Taranaki regions in the North Island, and north Canterbury and south Canterbury in the South Island. Herds were self-selected from those nominated by the coordinating veterinarians at each practice, and thought likely to meet the selection criteria of the study. Selection criteria were: being a client of the participating veterinary clinic, having >90% of the herd calving annually between 01 June and 30 November (i.e. seasonal, predominantly spring-calving herds), the KDM was expected to remain on the same site for the subsequent 2 years and was willing to (and considered likely to) follow the protocol for the study. Each farm was assumed to have one KDM. KDM of potentially eligible herds were identified by the coordinating veterinarians, and invited to a regional meeting prior to the commencement of the study, where the design of the study was outlined and data-recording commitments were explained. Herds in which KDM agreed to participate were then selected. Four selected herds were excluded before allocation because there was evidence of poor data collection or absence of on-farm data recording software. Of the remaining 144 KDM from herds allocated to groups included in the current study, 133 agreed to be interviewed, yielding a response rate of 90% (133/148).

2.3.3. *Development and administration of the questionnaire*

Data were collected using face-to-face structured interviews, using a questionnaire of the attitudes and priorities of the KDM, biophysical data about the farm, and aspects of disease control (Appendix 2). The interview captured data for the preceding 12 months, i.e. June 2008 to May 2009. Questions were developed based, in part, on validated questions used in questionnaires sent to farmers from previous studies. The questionnaire was pilot-tested with KDM on six farms not included in the study population, to assess whether their interpretation of the questions were consistent with the requirements of the study. Interviews were conducted with the KDM on each farm between May and July 2009. The interviews were undertaken by four trained technicians, one in each region, using a paper-based questionnaire. These technicians were provided with training in interview technique by a social scientist, and with detailed documentation about the interview process. The interviews took approximately 60 minutes. Subsequently, data were checked for missing values and ambiguous responses, some calculated fields were generated, e.g. stocking rate based on the number of cows and area of the farm, and KDM were re-contacted by technicians to seek clarification of particular responses if necessary.

Biophysical and demographic variables included region, effective area of the farm (number of hectares utilised for grazing milking cows), size and predominant breed of the herd, number of fulltime equivalents of staff employed in the previous season, farm business structure (family-owned, corporation or equity partnership) and production system (based on the five production systems identified by DairyNZ, and summarised in Table 2.1), and the occupation, age category (20–29, 30–39, 40−49 and ≥50), number of years dairy farming, and further education of the KDM. The order of the questions in the questionnaire was designed to avoid directing the thinking of KDM toward herd reproduction until reproduction-specific questions were asked. Some questions related to specific reproductive management options but these were not asked until after all higher-level views had been explored. The attitudes of the KDM toward farm management, priorities for the farm, sources of farming information, staffing, responsibility for tasks, opportunities to improve reproductive performance, and reproductive constraints were explored. Priorities and constraints were nominated and selected based on established reproductive risk factors in herds from an Australian study (Morton 2004) which represented the most recent work in this field for dairy herds in Australia and New Zealand. Key decision makers were asked to respond to attitude-rating questions using a Likert-type scale of 1 to 5 (Likert 1932), where 1 indicated very low importance, likelihood or priority, and 5 indicated very high importance, likelihood or priority. For example, one question was “Rate the importance of succession planning on your farm, where 1 is very low importance and 5 is very high importance”. All questions relating to attitude were independent of each other. When rating lists of choices regarding perceived priorities or constraints, the KDM was told that not all choices should be rated the same, but there was no restriction on how they rated each one.

2.3.4. *Statistical analysis*

All data were entered into a relational database written in structured query language designed for the National Herd Fertility Study, and analysed using R (R Development Core Team 2010; R Foundation for Statistical Computing, Vienna, Austria). The unit of analysis was the individual herd. Continuous data are described using means, SD and range, while categorical data are presented as percentages. Biophysical and demographic data were described, and univariate associations with region assessed using a linear regression model for continuous data, and χ2 tests for categorical data. Distributions of responses by KDM on the Likert-type scales were initially assessed using frequency plots. Associations between responses on the Likert-type scales and each demographic variable were assessed using univariate proportional-odds regression models.

Potential instability in the multi-level modelling caused by high correlation between predictor variables was avoided by selecting only the most plausible predictor variable from a correlated set. Correlation between potential predictor variables was investigated by assessing how much the deviance of a Gaussian or binomial generalised linear mixed model, as appropriate (using one variable to predict another), as a proportion of the deviance of the null model (the same model with the outcome only), was ‘explained’ by the predictor, giving a pseudo-R2 with a range of 0 to 1 (where 0 is no relationship, and 1 is complete collinearity). For example, the effective area of the farm and number of full-time staff were both highly correlated with the size of the herd (pseudo-R2=0.91 and 0.74, respectively), so the size of the herd was used as it was a more plausible indicator of attitudes.

The demographic variables selected from the univariate analysis were then assessed using a backwards stepwise model-building procedure and a multivariable proportional-odds regression model until all remaining predictor variables in the model were significantly associated with the attitude ($p<0.05$). The OR, calculated by exponentiating the coefficients from the regression models, estimate the odds of giving a particular Likert-type rating or higher (rather than a lower rating) for each group relative to a reference group. For example, the odds of KDM from the Waikato region rating their appetite to learn at or above any particular rating were three times higher than those of KDM from the Taranaki region. Proportional-odds ordinal-regression models assume that the OR are the same throughout the Likert-type scale (the proportional-odds assumption). To test this assumption, the ordinal likelihood ratios were compared with those from multinomial logistic models with the same covariates. Where a significant difference was identified between these models using likelihood ratio tests, a comparison recommended by Faraway (2006), the proportional-odds assumption was assumed to be violated, and the proportional-odds model was rejected. Results from the multinomial models are not presented.

2.4. Results

A total of 133 KDM were interviewed, of whom 35 (26%), 33 (25%), 33 (25%) and 32 (24%) were from the Waikato, Taranaki, north Canterbury and south Canterbury regions, respectively. Data were missing from only four attitudinal variables, constituting 0.02% of all attitudinal data.

Biophysical and demographic data reported by KDM interviewed in the study are presented in Tables 2.1 and 2.2. Table 2.1 also includes the regional averages for effective area of the farm, size of the herd, and cows per hectare taken from the national statistics for 2008/2009 published by the Livestock Improvement Corporation (Hamilton, New Zealand) and the national dairy levy body, DairyNZ (Anonymous 2009). Statistics for the herds in the study enrolled in the south Canterbury region were compared with those for the Waimate region in the national statistics, the most similar region geographically. In three of the regions, Waikato, Taranaki and north Canterbury, the mean size of herds in the study was larger than the regional average. Only in south Canterbury was there a smaller mean size of the herd in the study than the reported regional average.

There were no significant differences in reproductive management intervention choices between regions. Induction of parturition was used by 71% of herds, hormonal treatment of anoestrous cows during breeding by 79%, and routine examination for endometritis (based on the presence and nature of purulent discharge in the vagina) by 74%. However, the relatively less expensive measures of body condition scoring of cows and weighing of young stock were used by only 34% and 38% of KDM, respectively. When explored further, 80% of the KDM who measured body condition score of cows volunteered that the procedure was normally undertaken by an external person (normally a farm advisor) and that they were unsure how many cattle were scored and what method was employed to score each cow (visual-only, or a hands-on approach). Likewise, the weighing of young stock was undertaken by an external grazier in almost all cases, and again KDM were unsure about the protocols employed. In herds in the South Island, weighing of young stock was used by more KDM than body condition scoring of cows, whereas in the North Island, these procedures were used with similar frequency.

Table 2.1. Summary statistics for biophysical variables from 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009, presented for all herds in the study, and for herds in the study by region, compared with published industry means[a].

	All herds			Means for herds by region				
Biophysical variable of herd	**Mean**	**SD**	**Range**	**Waikato**	**Taranaki**	**North Canterbury**	**South Canterbury**	**P-value[b]**
Effective area of farm (ha)	164.4	72.6	50–350	126.6 (109)	114.5 (89)	221.5 (243)	195.2 (239)	<0.001
Size of herd	561	279	151–1,200	397 (313)	345 (237)	808 (723)	699 (743)	<0.001
Cows/ha	3.34	0.48	1.96–5.03	3.13 (2.93)	2.98 (2.68)	3.66 (3.35)	3.6 (3.14)	<0.001
Full-time staff equivalents (FTE)	3.3	1.3	1–7	2.7	2.3	4.4	3.8	<0.001
Cows/FTE	169	51	78–396	148	151	187	189	<0.001
Years dairy farming[c]	18.9	10.0	1–50	22.8	19.3	16.3	16.9	0.03

[a] Mean figures for regions are included in brackets, and were derived from *New Zealand Dairy Statistics 2008–09* (Anonymous 2009)

[b] P-values for effect of region as a covariate in linear regression models

[c] Years the key decision maker interviewed for each farm had been dairy farming

Table 2.2. Summary statistics for demographic variables for farms and key decision makers (KDM) from 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009, presented for all herds in the study, and for herds in the study by region.

		Herds by region				
Variable, and level	**No. (%) all herds**	**Waikato**	**Taranaki**	**North Canterbury**	**South Canterbury**	**P-value[a]**
Farm						
Farm business structure						0.02
Family owned farm	104 (78%)	91%	88%	67%	66%	
Non-family owned corporate farm	13 (10%)	9%	6%	9%	16%	
Equity partnership	16 (12%)	0%	6%	24%	19%	
Production system[b]						<0.001
1	11 (8%)	11%	21%	0%	0%	
2	14 (10%)	11%	24%	0%	6%	
3	38 (29%)	49%	18%	24%	22%	
4	38 (29%)	26%	15%	30%	44%	
5	32 (24%)	3%	21%	46%	28%	
Predominant breed						0.60
Friesian	51 (38%)	39%	36%	33%	47%	
Friesian x Jersey	70 (53%)	58%	49%	58%	44%	
Jersey	12 (9%)	3%	15%	9%	9%	
Key decision maker						
Occupation						0.01
Owner-occupier	77 (57%)	69%	63%	64%	34%	
Higher-order sharemilker[c]	25 (19%)	20%	31%	6%	19%	
Lower-order sharemilker[c]	17 (13%)	6%	6%	12%	28%	
Farm manager	4 (3%)	3%	0%	3%	6%	
Other (equity manager)	10 (8%)	3%	0%	16%	13%	

Age group (years)						0.02
20–29	12 (9%)	3%	13%	9%	13%	
30–39	36 (27%)	17%	22%	21%	50%	
40–49	56 (42%)	46%	41%	55%	28%	
≥50	28 (20%)	34%	25%	15%	9%	

[a] P-values for differences between regions were derived using χ^2 tests

[b] Production systems were defined as: 1 = no imported feed used to feed herd, 2 = 4–14% imported feed fed to dry cows and cows grazed off-farm, 3 = 10–20% of feed fed to extend lactation and dry cows, 4 = 20–30% fed to extend both ends of lactation and dry cows, 5 = 25–30% imported feed used throughout the whole year

[c] Higher-order sharemilkers were those that received >35% of farm income whereas lower-order sharemilkers were those that received ≤35% of farm income

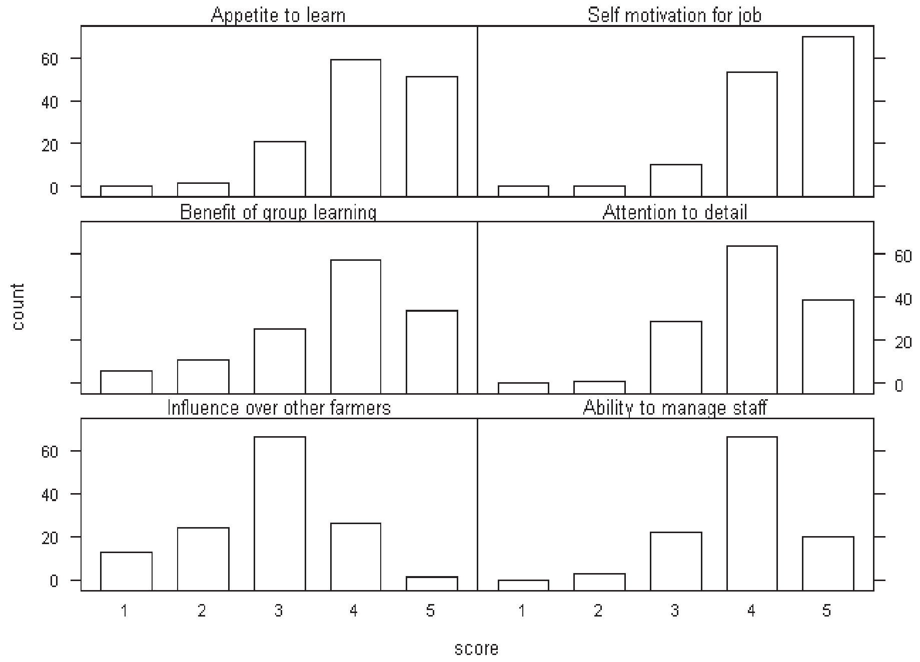


Figure 2.1. Distribution of responses by key decision makers managing 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009, asked to rate their attitude in relation to personality traits, using a Likert-type scale, where 1 = very low and 5 = very high.

2.4.1. *Attitudes*

Key decision makers were asked to rate 17 attitudes. Most rated their self-motivation for their job, their appetite to learn more, and their attention to detail as 4 or 5 on a scale of 5, where 5 was very high (Figure 2.1). There was a greater range of attitudes toward the perceived benefit gained from group learning experiences and their perceived ability to manage staff. KDM rated their perceived influence over other farmers as mostly 3. Regarding attitudes to the importance of various farm management practices, the importance of farm infrastructure, including tracks, fences, water systems and pastures, was rated highest and was least variable (Figure 2.2). The importance of timeliness of completing seasonal tasks, data recording, following proven protocols, delegation, and farm vehicles, tools and machinery was all rated as high or very high by the majority of farmers (median score=4). The importance of succession planning was rated below most other attitudes, across all regions. KDM not employing staff were not asked questions relating to staff management. More than 50% of KDM rated the current genetic quality, milksolids performance and reproductive performance of their herds as high or very high, and there was no significant difference between regions (Figure 2.3). The majority of KDM thought the reproductive performance of their herd had either stayed the same or improved over the last three seasons. The percentage of KDM who thought the reproductive performance of their herd was the same as (Waikato 18%, Taranaki 72%, north Canterbury 54%, and south Canterbury 46%) or better than (Waikato 67%, Taranaki 21%, north Canterbury 36%, south Canterbury 43%) the average for the district varied amongst regions. The remainder felt that the reproductive performance of their herd was lower than that of the regional average.

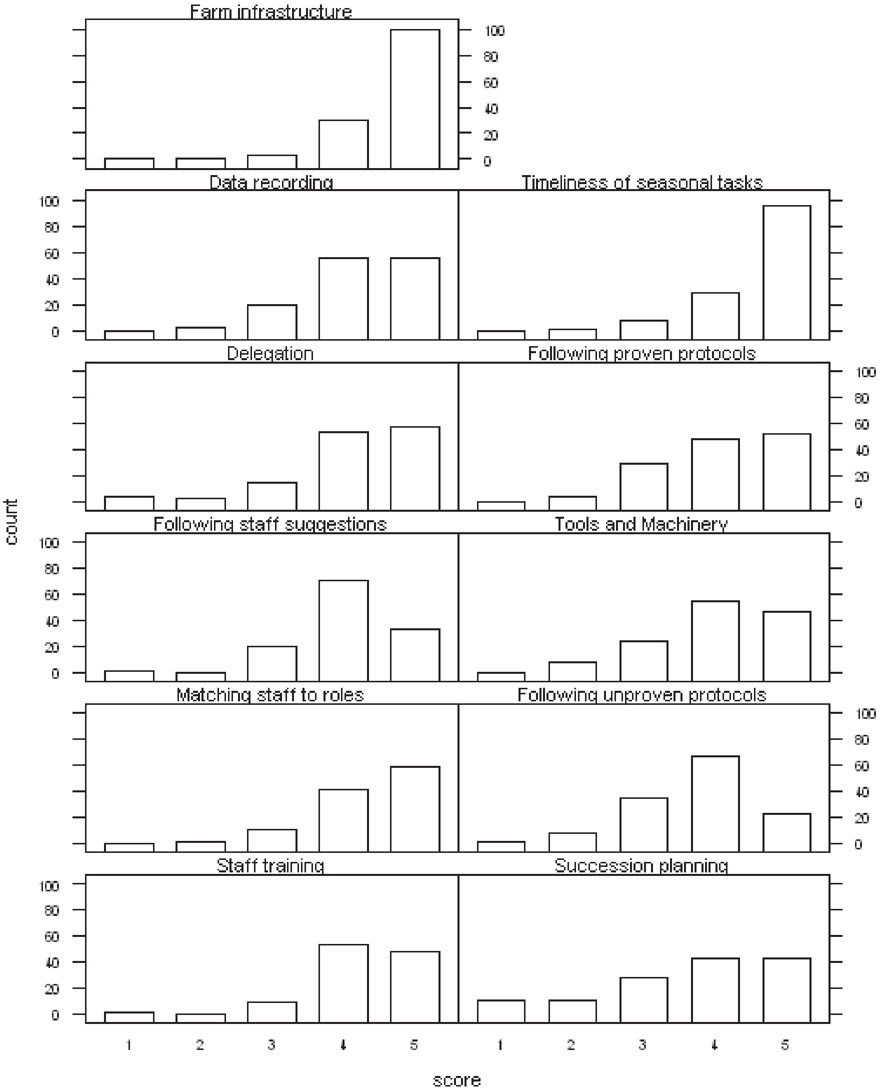


Figure 2.2. Distribution of responses by key decision makers managing 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009, asked to rate the importance of farm management practices or likelihood of them trying unproven ideas or technologies, using a Likert-type scale, where 1 = very low and 5 = very high.

2.4.2. *Priorities*

Ratings of the priority attributed to 10 areas of management over the next 3 years by KDM are presented in Figure 2.4. Collectively, 6/10 areas were rated as high priority (median Likert score=4 or 5), and three of those as very high priority (median Likert score of each=5). Overall, reproductive management of the herd was given the highest priority, with 127/133 (95%) KDM rating it as 4 or 5 (high or very high). This was closely followed by pasture management (123/133; 92%), business management of the farm (121/133; 91%), and animal health (117/133; 88%). Nineteen of 133 (14%) KDM felt that environmental sustainability on their farm and milk quality were a low or very low priority. Responses on management of staff as a priority were provided by the 110 KDM who employed staff. Of these, 87/110 (79%) rated management of staff as a high or very high priority (Likert score=4 or 5). Overall, the range of responses was narrower for management priorities than for attitudes (above); 50% of responses were ± 1 score for 4/10 management priorities.

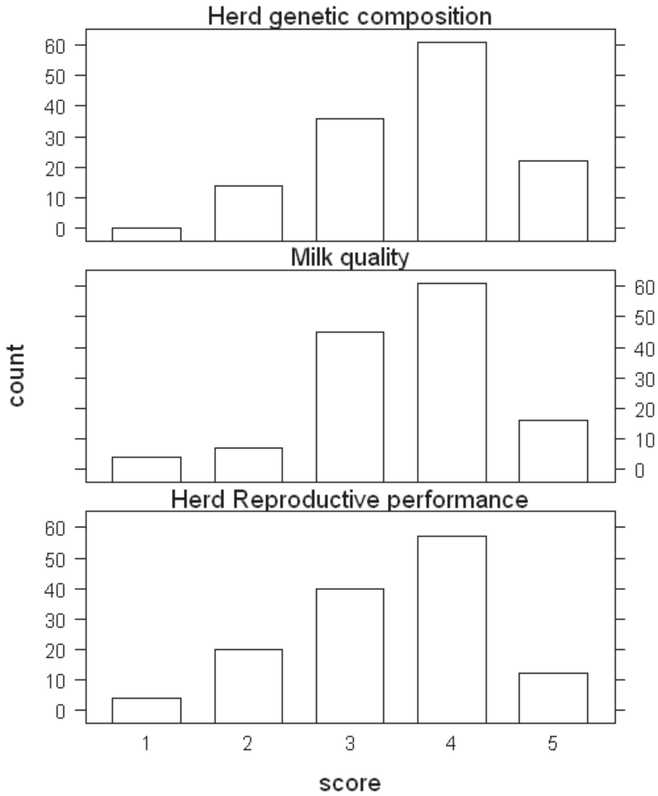


Figure 2.3. Distribution of responses by key decision makers managing 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009, asked to rate the current genetic quality, milksolids performance and reproductive performance of their herd, using a Likert-type scale, where 1 = very low and 5 = very high.

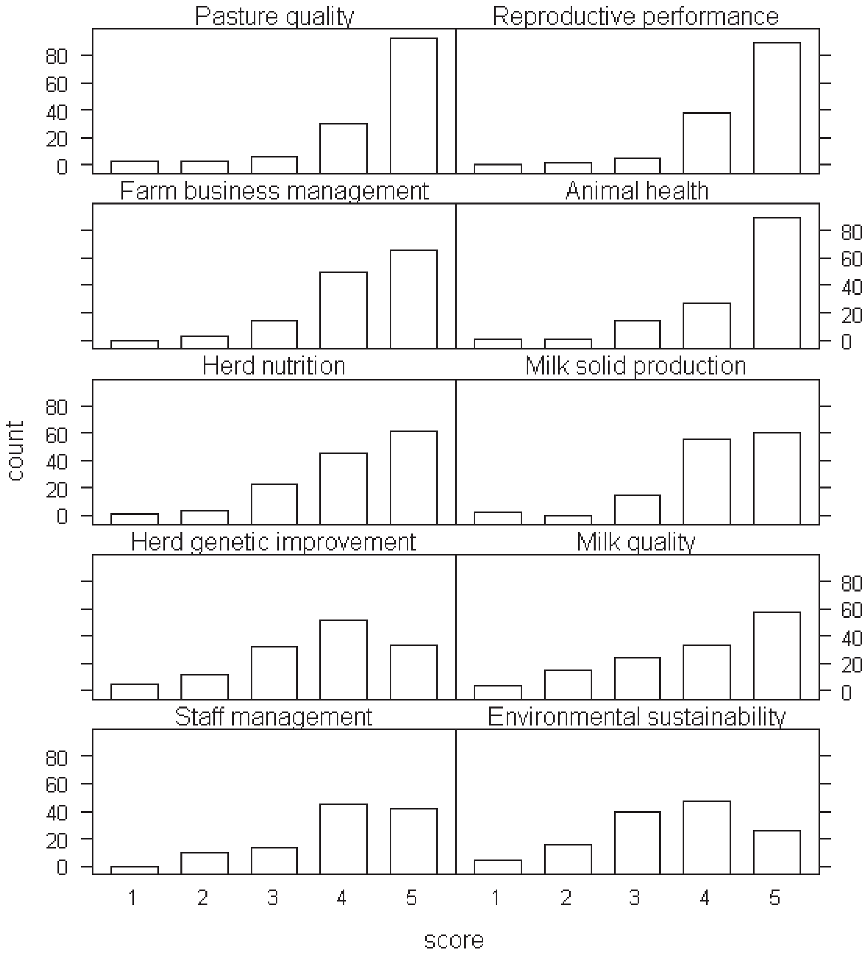


Figure 2.4. Distribution of responses by key decision makers managing 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009, asked to rate their management priorities over the next 3 years, using a Likert-type scale, where 1 = very low and 5 = very high.

2.4.3. *Constraints*

The likelihoods of identified risk factors perceived by KDM as constraints to their herd's reproductive performance over the previous two lactations are summarised in Figure 2.5. The spread of responses was wider than for management attitudes and priorities. Only the high prevalence of anoestrous cows in the herd during the first 3 weeks of mating, a protracted calving period (cows calving 9 weeks after the start of calving), and the body condition score of the herd had a median response of 3 (moderately likely constraint). The median response was <3 for all other constraints, i.e. these were perceived unlikely or very unlikely to be a constraint. Heat detection was considered unlikely to be a constraint to their herd's reproductive performance by 93/133 (70%) KDM, and almost all KDM considered artificial breeding and storage of semen were very unlikely to be constraints. When provided opportunity to suggest other likely constraints, 31/133 (23%) respondents did so; these were: nutrition and diet (8/31; 26%); the weather (8/31; 26%); infectious disease (5/31; 16%); physical characteristics of their farm (2/31; 6%); other farm-level management decisions made (9/31; 29%); and staffing (1/33; 3%). There was a regional trend in responses to this optional question; KDM from southern regions were more likely to consider nutrition and those in the northern regions were more likely to consider weather and management decisions to be constraints.

2.4.4. *Univariate and multivariable analyses*

One or more independent demographic variables were associated with all but five of the 40 attitudes, priorities and constraints assessed. There was no association between any of the demographic explanatory variables and the perceived importance of farm infrastructure, management of staff, choosing staff to match job roles, and farm business and herd reproduction as a priority for future management. Three of the remaining models did not meet the proportional-odds assumption, and were rejected. These were for the attention to detail, view on milksolids performance, and perceived importance by the KDM of artificial breeding and semen storage as a constraint on herd reproductive performance. Of the 32 attitudes, priorities and perceived constraints examined that had significant predictors, age group of the KDM was significantly associated with 24, region with 10, and the occupation of the KDM with 5. Tables 2.3, 2.4 and 2.5 show the results of the multivariable models of responses for 29 attitudes, priorities and perceived constraints examined, respectively; results of the remaining three are presented here as follows.

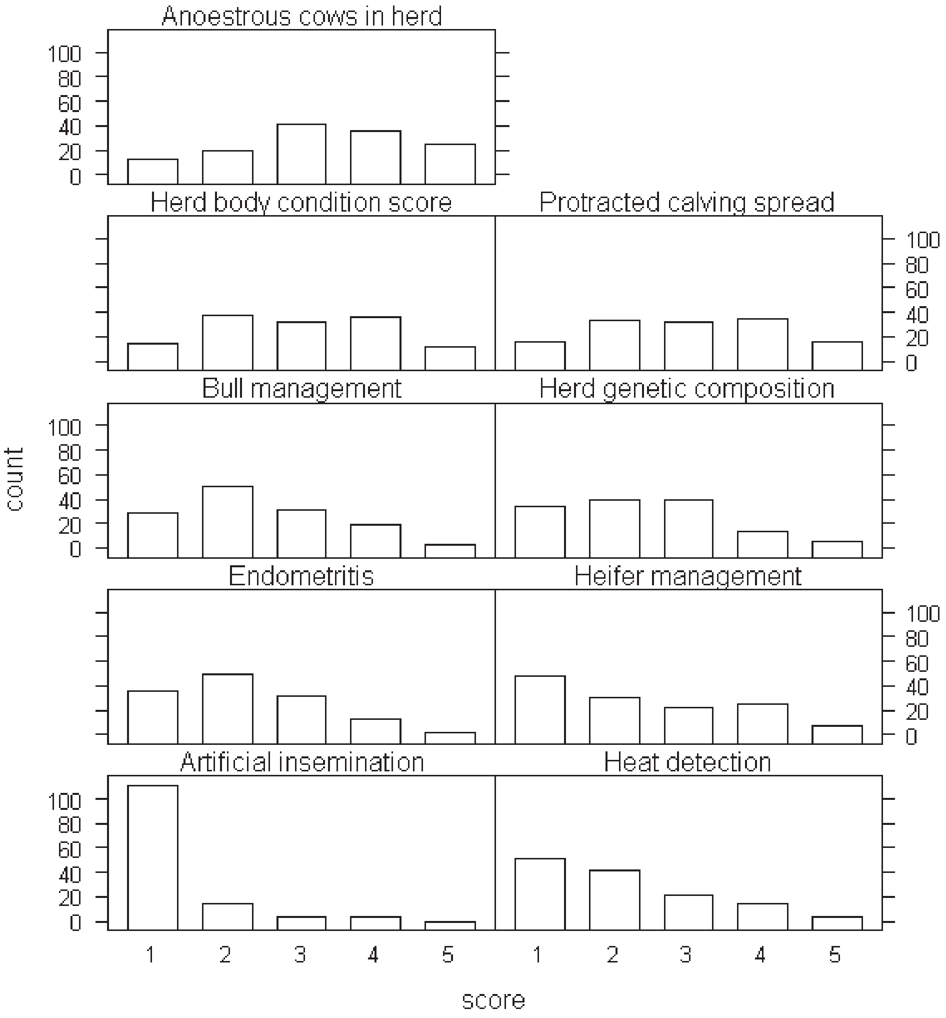


Figure 2.5. Distribution of responses by key decision makers managing 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009, asked to rate the likelihood of factors being a constraint to the reproductive performance of their herd over the previous 2 years, using a Likert-type scale, where 1 = very low and 5 = very high.

Table 2.3. Odds ratios (and 95% CI) of significant predictors for rating attitudinal and management variables (using a Likert-type scale where 1 = very low and 5 = very high) by key decision makers (KDM) from 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009.

Attitude	Predictor, and level	OR (95%CI)	P-value
Self-motivation for job	Herd size (per SD of herd size)[b]	1.62 (1.15–2.32)	0.006
Appetite to learn	Region[c]		0.007
	Waikato	3.01 (1.21–7.66)	
	Taranaki	Ref	
	North Canterbury	4.57 (1.78–12.14)	
	South Canterbury	3.73 (1.47–9.76)	
Influence over other farmers	KDM age (years)		0.015
	20–29	Ref	
	30–39	1.79 (0.51–6.34)	
	40–49	1.76 (0.52–5.92)	
	≥50	2.18 (0.58–8.19)	
Importance of timeliness of seasonal tasks	Region[c]		<0.001
	Waikato	6.11 (2.13–19.63)	
	Taranaki	Ref	
	North Canterbury	4.33 (1.6–12.57)	
	South Canterbury	6.76 (2.25–23.61)	
Importance of adherence to proven protocols	KDM occupation		0.008
	Owner-occupier	Ref	
	Higher-order sharemilker[d]	1.19 (0.49–2.90)	
	Lower-order sharemilker[d]	3.00 (1.00–9.68)	
	Farm manager	7.57 (2.02–37.4)	
	KDM age (years)		0.020
	20–29	Ref	
	30–39	1.87 (0.51–7.00)	
	40–49	2.01 (0.54–7.66)	
	≥50	3.48 (0.87–14.45)	
Likelihood of trying unproven ideas or technologies	Production system[e]		0.008
	1	Ref	
	2	3.47 (0.78–16.33)	
	3	7.66 (2.02–30.95)	
	4	6.15 (1.61–24.93)	
	5	11.1 (2.78–47.3)	

Benefit of group learning with farmers	KDM age (years)		0.008
	20–29	2.04 (0.64–6.70)	
	30–39	1.75 (0.78–3.94)	
	40–49	Ref	
	≥50	2.27 (0.95–5.54)	
	Production system[e]		0.03
	1	1.83 (0.53–6.39)	
	2	1.67 (0.51–5.59)	
	3	4.21 (1.73–10.58)	
	4	Ref	
	5	1.54 (0.61–3.95)	
	Herd size (per SD of herd size)[b]	1.62 (1.10–2.40)	0.01
Importance of farm machinery	KDM age (years)		<0.001
	20–29	3.27 (1.02–11.17)	
	30–39	2.46 (1.11–5.56)	
	40–49	Ref	
	≥50	1.47 (0.62–3.5)	
Importance of data recording	Region[c]		0.01
	Waikato	4.48 (1.71–12.16)	
	Taranaki	Ref	
	North Canterbury	3.62 (1.41–9.63)	
	South Canterbury	2.76 (1.02–7.63)	
	KDM age (years)		0.02
	20–29	1.71 (0.53–5.84)	
	30–39	1.55 (0.67–3.67)	
	40–49	Ref	
	≥50	1.5 (0.61–3.76)	
Importance of staff training	KDM occupation		0.03
	Owner-occupier	1.38 (0.51–3.86)	
	Higher-order sharemilker[d]	Ref	
	Lower-order sharemilker[d]	3.4 (0.88–13.96)	
	Farm manager	6.1 (1.49–29.02)	
Importance of staff suggestions	KDM age (years)		0.03
	20–29	Ref	
	30–39	5.4 (1.39–21.84)	
	40–49	4.14 (1.14–15.57)	
	≥50	5.73 (1.4–24.39)	

Importance of delegation	KDM age (years)		0.03
	20–29	3.31 (0.62–18.82)	
	30–39	3.4 (0.97–12.37)	
	40–49	1.62 (0.6–4.38)	
	≥50	Ref	
	Years dairy farming[f]	1.07 (1.02–1.12)	0.009
	Production system[e]		0.04
	1	Ref	
	2	4.63 (0.95–23.71)	
	3	4.23 (1.13–16.53)	
	4	4.25 (1.14–16.44)	
	5	8.89 (2.28–36.61)	
Importance of succession planning	KDM age (years)		0.003
	20–29	1.14 (0.35–3.92)	
	30–39	1.94 (0.91–4.18)	
	40–49	Ref	
	≥50	1.58 (0.69–3.7)	

[a] P-value of the likelihood-ratio test indicating that a model including the variable improved the fit of the model significantly, with an alpha (type I) error equivalent to p

[b] The odds of rating self-motivation at any particular rating or higher increased by 1.62 for every increase in herd size of 279 cows (SD of size of herd in the study, from Table 1)

[c] The predictor represented the effect of the four regions examined in the study

[d] Higher-order sharemilkers were those that received >35% of farm income; lower-order sharemilkers were those that received ≤35% of farm income

[e] Production systems were defined as: 1 = no imported feed used to feed herd, 2 = 4–14% imported feed fed to dry cows and cows grazed off-farm, 3 = 10–20% of feed fed to extend lactation and dry cows, 4 = 20–30% fed to extend both ends of lactation and dry cows, 5 = 25–30% imported feed used throughout the whole year

[f] Odds of reporting any particular rating or higher for every extra year dairy farming

Ref = reference (for all variables, the level with the lowest odds was used as the reference category)

Table 2.4. Odds ratios (and 95% CI) of significant predictors for increased rating of perceived priorities (using a Likert-type scale, where 1 = very low and 5 = very high) by key decision makers (KDM) from 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009.

Priority	Predictor, and level	OR (95%CI)	P-value[a]
Animal health	Region[b]		0.028
	Waikato	Ref	
	Taranaki	2.49 (0.9–7.16)	
	North Canterbury	1.55 (0.57–4.31)	
	South Canterbury	6.68 (1.77–31.14)	
	KDM occupation		0.013
	Owner-occupier	Ref	
	Higher-order sharemilker[c]	1.57 (0.53–5.15)	
	Lower-order sharemilker[c]	28.63 (3.2–737.95)	
	Farm manager	1.7 (0.44–7.54)	
	KDM age (years)		0.015
	20–29	Ref	
	30–39	8.16 (1.52–48.61)	
	40–49	11.42 (2.07–70.7)	
	≥50	8.02 (1.38–51.85)	
Nutrition management	Region[b]		0.001
	Waikato	Ref	
	Taranaki	2.85 (1.15–7.25)	
	North Canterbury	1.82 (0.72–4.65)	
	South Canterbury	8.34 (2.9–25.62)	
	KDM age (years)		0.003
	20–29	Ref	
	30–39	2.53 (0.74–8.75)	
	40–49	1.87 (0.59–5.97)	
	≥50	3.61 (0.98–13.64)	
Environmental sustainability	Region[b]		<0.001
	Waikato	Ref	
	Taranaki	4.79 (1.93–12.21)	
	North Canterbury	1.22 (0.5–3.01)	
	South Canterbury	9.5 (3.5–26.91)	
	KDM age (years)		0.016
	20–29	Ref	
	30–39	1.29 (0.37–4.61)	
	40–49	1.71 (0.51–5.86)	

	≥50	1.7 (0.46–6.47)	
Herd genetics	Region[b]		<0.001
	Waikato	Ref	
	Taranaki	3.09 (1.26–7.72)	
	North Canterbury	1.01 (0.41–2.47)	
	South Canterbury	5.88 (2.21–16.22)	
	KDM age (years)		0.004
	20–29	1.26 (0.36–4.44)	
	30–39	Ref	
	40–49	1.26 (0.55–2.86)	
	≥50	1.52 (0.59–3.96)	
	Further education[d]	0.43 (0.21–0.87)	0.018
Milksolids performance	Region[b]		0.004
	Waikato	Ref	
	Taranaki	4.1 (1.56–11.17)	
	North Canterbury	2.65 (1–7.23)	
	South Canterbury	5.84 (2.05–17.53)	
	KDM age (years)		<0.001
	20–29	Ref	
	30–39	5.59 (1.58–20.66)	
	40–49	10.62 (2.72–44.4)	
	≥50	26.29 (4.65–166.77)	
	Years dairy farming[e]	0.92 (0.87–0.97)	0.002
Milk quality	Region		<0.001
	Waikato	1.51 (0.64–3.63)	
	Taranaki	9.28 (3.44–26.66)	
	North Canterbury	Ref	
	South Canterbury	10.78 (3.85–32.34)	
	KDM age (years)		<0.001
	20–29	Ref	
	30–39	3.33 (0.93–11.93)	
	40–49	6.01 (1.7–21.6)	
	≥50	4.43 (1.13–17.61)	
Pasture management	KDM occupation		0.036
	Owner-occupier	1.54 (0.62–3.73)	
	Higher-order sharemilker[c]	Ref	
	Lower-order sharemilker[c]	11.89 (1.97–230.09)	

	Farm manager	2.3 (0.55–12.03)	
Staff management	KDM occupation		<0.001
	Owner-occupier	Ref	
	Higher-order sharemilker[c]	2.38 (0.85–7.01)	
	Lower-order sharemilker[c]	18.03 (4.47–84.67)	
	Farm manager	6.98 (1.96–27.83)	
	KDM age (years)		0.001
	20–29	Ref	
	30–39	1.54 (0.38–6.22)	
	40–49	8.13 (1.78–38.42)	
	≥50	2.93 (0.63–13.96)	

[a] P-value of the likelihood-ratio test indicating that a model including the variable improved the fit of the model significantly, with an alpha (type I) error equivalent to p

[b] The predictor represented the effect of the four regions examined in the study

[c] Higher-order sharemilkers were those that received >35% of farm income; lower-order sharemilkers were those that received ≤35% of farm income

[d] The odds of increasing a ranking of a priority if the key decision maker had undertaken a form of further education

[e] Odds of reporting any particular rating or higher for every extra year dairy farming

Ref = reference (for all variables, the level with the lowest odds was used as the reference category)

Table 2.5. Odds ratios (and 95% CI) of significant predictors for increased rating of the perceived likelihood of constraints affecting herd reproductive performance (using a Likert-type scale, where 1 = very unlikely and 5 = very likely) by key decision makers (KDM) from 133 seasonal-calving, pasture-based dairy herds from four regions in New Zealand, enrolled in the National Herd Fertility Study during 2009.

Factor affecting reproduction	Predictor, and level	OR (95%CI)	P-value[a]
Anoestrous cows in the herd	KDM age (years)		0.018
	20–29	2.49 (0.8–7.93)	
	30–39	Ref	
	40–49	1.38 (0.66–2.88)	
	≥50	1.12 (0.43–2.90)	
Low body condition score of herd	KDM age (years)		0.031
	20–29	1.08 (0.32–3.58)	
	30–39	1.2 (0.49–2.96)	
	40–49	1.41 (0.63–3.18)	
	≥50	Ref	
Management of bulls	Farm business type		0.031
	Family owned	Ref	
	Non-family owned	2.81 (0.99–8.15)	
	Equity partnership	2.82 (1.04–7.69)	
	KDM age (years)		0.006
	20–29	1.11 (0.31–3.89)	
	30–39	Ref	
	40–49	1.21 (0.56–2.62)	
	≥50	1.92 (0.75–4.99)	
Protracted calving pattern	KDM age (years)		0.002
	20–29	2.83 (0.76–10.69)	
	30–39	2.02 (0.81–5.05)	
	40–49	2.39 (1.03–5.61)	
	≥50	Ref	
Endometritis	KDM age (years)		0.003
	20–29	5.39 (1.44–20.84)	
	30–39	2.04 (0.70–6.00)	
	40–49	3.14 (1.19–8.58)	
	≥50	Ref	
	Further education[b]	3.3 (1.57–7.15)	0.002
	Production system[c]		0.042
	1	1.83 (0.45–7.41)	
	2	2.57 (0.65–9.87)	
	3	3.66 (1.52–9.02)	

	4	Ref	
	5	1.04 (0.41–2.67)	
	Herd size (per SD of herd size)[d]	1.93 (1.29–2.92)	0.001
Heat detection	KDM age (years)		0.006
	20–29	2.87 (0.91–9.15)	
	30–39	1.26 (0.59–2.70)	
	40–49	Ref	
	≥50	1.57 (0.66–3.76)	
Heifer size at calving	Region[e]		0.033
	Waikato	3.57 (1.38–9.5)	
	Taranaki	1.18 (0.45–3.14)	
	North Canterbury	1.85 (0.74–4.7)	
	South Canterbury	Ref	
	KDM age (years)		<0.001
	20–29	6.57 (1.83–24.59)	
	30–39	3.64 (1.27–10.92)	
	40–49	4.03 (1.58–10.82)	
	≥50	Ref	
Genetic quality of herd	KDM age (years)		0.031
	20–29	1.28 (0.38–4.26)	
	30–39	1.55 (0.61–3.98)	
	40–49	1.4 (0.59–3.34)	
	≥50	Ref	

[a] P-value of the likelihood-ratio test indicating that a model including the variable improved the fit of the model significantly, with an alpha (type I) error equivalent to p

[b] The odds of increasing a ranking of a priority if the key decision maker had undertaken a form of further education

[c] Production systems were defined as: 1 = no imported feed used to feed herd, 2 = 4–14% imported feed fed to dry cows and cows grazed off-farm, 3 = 10–20% of feed fed to extend lactation and dry cows, 4 = 20–30% fed to extend both ends of lactation and dry cows, 5 = 25–30% imported feed used throughout the whole year

[d] The odds of rating self-motivation at any particular rating or higher increased by 1.62 for every 279 cows increase in herd size of 279 cows (SD of size of herd in the study, from Table 1)

[e]. The predictor represented the effect of the four regions examined in the study

Age group was a predictor for how KDM rated the reproductive performance of their herd ($p<0.05$). Relative to older age groups, younger (20–29-year-old) KDM were least likely to rate their herd's reproductive performance at or above any particular rating compared with those 30–39, 40–49, and ≥50 years old (OR 2.2, 95% CI=0.7–7.5; OR 2.10, 95% CI=0.7–6.8; and OR 3.2, 95% CI=0.9–11.6 for these groups relative to 20–29-year-olds, respectively). KDM aged 30–39 years were more likely (OR 1.4 (95% CI=0.4–5.2); $p<0.05$) to rate their herd's change in reproductive performance as improved in the last 3 years than those aged 20–29 years, and the other age groups were intermediate. Region was more strongly associated than age group with the perception of a KDM of their herd's reproductive performance being better than the average for the district. KDM in the Taranaki region were less likely to rate their herd's reproductive performance as better than the average for the district than those in the Waikato, north Canterbury, or south Canterbury (OR 9.8, 95% CI=3.5–29.6; OR 2.2, 95% CI=0.82–6.3; and OR 3.0, 5% CI=1.1–8.7 for these regions relative to Taranaki, respectively; p<0.05).

Key decision makers aged 40–49 years and those who managed large and/or intensive dairy farms (production system 4 and 5) were least likely to consider group learning important. Group learning was rated most important by KDM ≥50 years old, closely followed by those 20–29 years old, and by those who man- aged semi-intensive production systems (system 3) and/or smaller herds.

Staff training was considered most important by farm managers and least important by higher-order sharemilkers and owner occupiers. All age groups >29 years old were more likely to rate the importance of staff suggestions highly than 20–29-year-olds (p=0.03). Younger (20–29 years old) KDM rated the constraints to reproductive performance as more likely than older KDM in 7/8 models. In five of these models, the odds of this younger age group rating constraints at or above any particular rating were twice those for the other age groups.

2.5. Discussion

The aim of this study was to examine attitudes, priorities, and constraints pertaining to herd reproductive management perceived by KDM managing seasonal-calving, pasture-based dairy herds in four regions of New Zealand, and to explore how these varied with demographic and biophysical factors. The overarching aim was to identify possible predictors of attitude potentially important when designing and implementing management extension programmes to influence KDM, and to help advisors improve the focus of their advice. This is the first published attempt to formally characterise the attitudes of KDM managing dairy herds in New Zealand, hence there are no comparative data. The interpretation of these results is therefore drawn with development of extension programmes in mind.

The farms included in this study were intended to be representative of those in the regions they were drawn from. However, a number of potential biases should be considered. The most obvious are the enrolment criteria. The requirement for good-quality data to be collected on-farm for the duration of the study resulted in selection bias towards KDM that the local veterinarians perceived to be most capable of complying. This may explain the slightly larger herd sizes and areas of the farms included in the study than reported in regional statistics (Anonymous 2009). The opinions of

KDM on the importance of data recording varied amongst region and age category but not by size of herd, suggesting that any bias relating to size of herd was unlikely to have biased the conclusions. It could be suggested that KDM willing to collect data are more likely to remain in business in the future, and hence should be the focus of research.

Other biases could have been introduced by veterinarians excluding potential clients they perceived to be difficult to work with, and variation between interviewers, which was totally confounded with region, as only one interviewer per region was used. The study employed local technicians in each region and provided their training. The degree of familiarity each technician had with the KDM they interviewed and their technical understanding of dairy farming also probably varied, and may have affected responses recorded. To mitigate this, interviewers were alerted to this risk, and all questions were discussed during their training to reduce variation in interpretation of responses by KDM. Regular communication between interviewers and the study's management team during the interviewing period helped reduce variability between regions by addressing issues as they were encountered, across the study. Answers varied on average by 13.4% when farmers were interviewed twice in one year as part of a mastitis study (Schukken *et al.* 1989). Similar variation was reported in an earlier study of responses to an interview (Horwitz and Yu 1985). In the study by Schukken *et al.* (1989), variation in responses was an accumulation of actual differences in the farmer's answer, and different interpretations by the interviewers of the same answer given by the farmer. Those authors examined objective management choices and performance indicators, whereas the current study was principally concerned with the views and attitudes of the KDM at the start of the period of the study. The repeatability of responses in the current study may have been lower due to the subjective nature of the topics. The views of the KDM were largely collected using Likert-type scales, which meant there was less opportunity for interviewer technique resulting in bias than there might have been with open-ended questions. However, a limitation of the Likert-type scale is acquiescence bias, a tendency of respondents to agree with the statements and gravitate toward the optimal end of the scale (Likert 1932). The design of questions and training of interviewers attempted to minimise this issue in the study reported here.

More than half the KDM rated their herd's reproductive performance as high or very high; none rated it as very low, and 75% considered their herd's reproductive performance had either stayed the same or improved over the previous 3 years. These results are contrary to those from a recent national needs-analysis survey conducted with dairy farmers in New Zealand (Burke *et al.* 2008); in which respondents indicated they were generally dissatisfied with their herd's reproductive performance. This difference may be due to use of different sample-selection processes, and that in the current study, KDM were asked to rate their herd's reproductive performance before they were asked about constraints and management aspects of reproduction. KDM similarly rated the quality of genetics and milksolids performance of their herds (Figure 2.3).

Apparent discrepancy between evidence that the fertility of dairy cows is declining in New Zealand (Harris *et al.* 2006) and perceptions by KDM about reproductive performance in their herds in the current study highlights a need for advisors and extension programmes to provide objective benchmarking of herd reproductive performance (Bigras-Poulin *et al.* 1985ab). Adult learning studies identify 'establishing dissatisfaction with the status quo' as a fundamental criterion for change (Holifield and Masters 1993). In the 2 years preceding the study presented here, there had been prolonged periods of drought; these had resolved in the year immediately prior to when the questionnaire was administered, and this may explain the perceived improvement in reproductive performance reported by KDM in the current study. When asked how the reproductive performance of their herd compared with that of other herds in the district, 123/133 (92%) considered their herd was either the same or better. Most based this response on conversations with other farmers or local veterinarians, and regarded their herd's final empty rate, i.e. the proportion of cows not pregnant at the end of the mating period, as the chief measure of performance. However, as the length of the mating period varies between herds, this measure is not easily comparable. That placed further responsibility on the rural professional to be able to provide appropriate benchmarking measures for comparing performance between herds, and within herds, over time, e.g. the 6-week in-calf rate. The importance of providing a realistic frame of reference when veterinarians are advising farmers on herd health has been highlighted by Lam *et al.* (2011).

The perceived constraints on reproductive performance rated most likely were anoestrous cows within the herd before and during mating, protracted calving pattern, and low body condition score of the herd. Despite identifying anoestrous cows as a likely constraint to reproductive performance, most KDM considered heat detection was unlikely or very unlikely to be a constraint, similar to findings in a recent farmer needs-analysis survey (Burke *et al.* 2008). In that survey, respondents were offered a series of options, and prioritised balancing nutrition, managing foreign genetics, and body condition score of cows as the most important barriers to meeting reproductive targets. Within the current study, the options offered as constraints were based on barriers identified in the InCalf extension programme (Morton 2004), that provided insight into constraints perceived by farmers within that framework. Amongst the additional constraints proposed by the KDM themselves in this study, the most frequent was nutrition, consistent with the farmer needs-analysis results reported by Burke *et al.* (2008). The use of veterinary interventions (induction of parturition, hormonal treatment of anoestrous cows, and routine treatment for endometritis) was similar between regions, and this may have reflected similar levels of advice and service provided by veterinary practices in relation to these interventions, across regions.

When asked to prioritise areas of management for the future, ratings were consistently high, with 3/10 options having a median rating of 5 (very high priority). This could have reflected fairly homogeneous positive attitudes toward farming amongst KDM in this study. However, this may also have been due, in part, to acquiescence bias. In this study, management of reproduction was prioritised the highest of the options offered, with 89/133 (67%) respondents rating it 5/5. Of the respondents that employed staff, 87/110 (79%) rated the management of staff as a high or very high priority. However, ratings of attitudes toward the importance of staff training, choosing staff to match roles, and importance of staff suggestions were lower. A recent study in Australia highlighted that identifying the key members of the on-farm team who contributed to decisions about mastitis and milk quality, and involving them in the consultation, increased the success of a programme to improve milk quality (Penry *et al.* 2011). When seeking to improve herd reproductive performance, engaging all staff on the farm is likely to be a critical part of achieving improvement. The occupation of the KDM was a significant predictor of the perceived value of staff training in the multivariable models. The higher rating from managers could reflect desire for training themselves as well as for their staff.

Multivariable modelling was undertaken to allow assessment of the association of various demographic variables with attitudes, priorities and constraints perceived by KDM. Overall, 30–39- and 40–49-year-olds rated the attitudinal statements offered more highly than 20–29-year-olds. Interestingly, the 20–29-yearold age group also had half the odds of rating their herd reproductive performance as high or higher than any particular rating relative to all other age groups. Lower rating of performance and greater benefit perceived from group learning may make this age group more responsive to advice and extension programmes designed to improve herd reproductive performance. Also notable was that lower-order sharemilkers (KDM with ≤35% stakehold in the farm and stock) and older KDM (>29 years old) were more likely to use proven management protocols than owner-operators or younger KDM, respectively. KDM managing more intensive production systems (i.e. >2) were more likely to try unproven ideas or technologies, probably reflecting the fact that intensive dairy systems depart from the traditional dairy farm systems and practices in New Zealand.

The results from this study indicated that the age of KDM affected their attitudes, priorities and perceived constraints. Furthermore, both the 20–29- and ≥50-year-old age groups generally reported lower ratings for many of the attitudes investigated. Such U-shaped responses could be described using age-period cohort methodology in future studies, in which the separate effects of age and cohort can be identified using a longitudinal study protocol (O'Brien 2000; Harding 2009). This methodology accounts for 'cohort succession, ageing, and period-specific historical events to explain social and demographic change (Smith 2008). We propose that these effects of age group were both due to age and cohort, with changes in attitude differentiated by experience and maturity (Brockmann 2009), and the effect of recent economic downturn, for example, on different age groups. Extension programmes should be developed considering the age group of the KDM. Region had a lesser effect than age, but should also be considered in the development of extension programmes.

In conclusion, KDM generally rated the reproductive performance of their herds as high or very high although, paradoxically, reproduction was listed as the highest priority for future improvement. Without challenging this rating of perceived performance, uptake of reproductive advice and extension programmes, and consequent positive behavioural change, is less likely. Appropriate objective benchmarking of actual reproductive performance may help KDM understand the potential for and consequent benefits of improvement.

Extension approaches should be developed that are appropriate to age group, as it was evident that the attitudes, priorities and perceived constraints of KDM varied with age. The value of staff suggestions and training was rated lower than many other attitudes assessed. Accordingly, extension programmes that encourage KDM to focus on engaging all farm staff may be more successful. Finally, biophysical and demographic factors such as the size of the herd and the occupation of the KDM did not account for important variation in attitude. This indicates that extension approaches stratified on biophysical factors such as the size of the herd, e.g. extension programmes for a large farm *vs.* a small farm, may not be required.

CHAPTER 3

Reproductive performance of seasonal-calving, pasture-based dairy herds in four regions of New Zealand

T S Brownlie, J M Morton, C Heuer, J Hunnam and S McDougall

3.1. Abstract

AIMS: The primary objective of this study was to describe the reproductive performance of a selection of New Zealand dairy herds in 2009/10 and 2010/11. A secondary objective was to explore associations between a number of biophysical and socio-demographic herd-level variables and herd-level reproductive outcomes.

METHODS: Seasonal-calving, pasture based herds from the Waikato (n=16), Taranaki (n=16), North Canterbury (n=17) and South Canterbury (n=14) regions of New Zealand were enrolled as part of a larger study. Submission, conception and pregnancy rates ('in-calf rates') were calculated for 2009/10 and 2010/11 based on cow-level records and from the results of strategically timed pregnancy diagnoses. Additional herd-level information was collected during interviews with the herd key decision maker (KDM). Associations between independent variables and reproductive performance were examined using univariate and multivariable generalised linear models.

RESULTS: Mean 6 week in-calf rate of the herds over both study years was 67 (range 46 - 86) %, mean 3 week submission rate was 81 (range 44 - 95) % and mean first service conception rate was 48 (range 25 - 71) %. On univariate analyses, the herd's 6 week in-calf rate in the year before enrolment (2008/09) was the strongest identified predictor of each of submission rate, conception rate and 6 week in-calf rate (all $p<0.01$), while other predictor variables considered were non-significant ($p \geq 0.07$).

From multivariable modelling, herds using extensive production systems had better reproductive performance than more intensively managed systems. Higher 3 week submission rate were achieved in herds where the KDMs were farm managers rather than owner operators, and where the predominant breed was Jersey rather than Friesian.

CONCLUSIONS: The New Zealand dairy industry has set a target for a mean 6 week in-calf rate of 78% with minimal hormonal intervention by 2016. Achieving this target appears unlikely unless there are substantial increases in both submission rates and conception rates. The mean 6 week in-calf rate of New Zealand dairy herd does not appear to have changed in the last decade. However the large differences between herds indicate that better reproductive performance is currently possible in many herds. The herd's 6 week in-calf rate in the year before enrolment (2008/09) was the strongest identified predictor of current 6 week in-calf rate, suggesting that rate of improvement in reproductive performance would be slow within current management systems unless substantial changes in management decisions reducing calving pattern are introduced.

3.2. Introduction

Knowledge of the reproductive performance of dairy herds is important for policy makers allocating resource for research and extension, and for veterinarians and for herd owners when assessing current herd performance and future management priorities. The last detailed herd-level assessment of reproductive performance of dairy herds in New Zealand occurred over 10 years ago (Xu and Burton, 2003). Since then, there have been increases in herd size, intensification of feeding, increases in cow production and changes in farm business management structures.

In a recent survey of the views of key decision makers (KDMs) from 133 New Zealand dairy farms, management of reproduction in their herd was rated as one of their highest priorities for change, with 127 (95%) rating herd reproduction a high or very high priority, Conversely, over half of these farmers also rated the current reproductive performance of their herd as high or very high (Chapter 2). In most cases, the actual performance of these herds did not meet the industry targets in most cases (Xu & Burton 2003). The apparent paradoxes of farmer perception of their herds' high reproductive performance, and still rating change in reproductive management as highly important, despite not meeting industry targets, might reflect a lack of understanding of optimal reproductive performance by dairy farmers.

In the most recent multi-herd study of dairy herds in New Zealand, the mean proportion of cows pregnant in the first 42 days of the mating period (the '6 week in-calf rate') was 68%, but this was highly variable between herds (Xu & Burton 2003). An earlier longitudinal study found that the percentage of cows that calved within the first 42 days of the calving period (a measure influenced in part, by the 6 week in-calf rate of the previous season) declined from 70% in 1991 to 50% in 2001 (Harris 2005). Reversing this apparent decline in proportion of cows pregnant within the first 6 weeks of the breeding program is a potential major economic opportunity for the New Zealand dairy industry. Simulation modelling has estimated that there is a $4 per cow increase in return for every 1% gain in 6 week in-calf rate, due to increased total lactation production at cow-level and reduced costs of involuntary culling (Beukes *et al.* 2010). Moreover, additional gains could be expected through increased voluntary culling; improved genetic gains made through increased use of artificial insemination and better pasture utilization. An increased 6 week in-calf rate may also reduce the use of hormonal intervention as a management tool (both for induction of parturition and treatment of anoestrus cows) (Rhodes*, et al.* 1998; Compton & McDougall 2010). These have been identified by the industry as potential risks to market access. Improving reproductive performance will be of particular importance if international market forces dictate the removal of hormonal interventions as a means of manipulating calving pattern.

To assess trends in reproductive performance nationally, agreed measures of national herd performance and understanding of the current levels of performance are both required. In 2005, the New Zealand dairy industry set a target national mean 6 week in-calf rate of 78%, to be achieved by 2016 with minimal hormonal intervention (Anonymous 1999). This was based on the mean 6 week in-calf rate of the top quartile of herds in the study of Xu and Burton (2003). The targets set for 3 week submission rate and first service conception rate were 90% and 60%, respectively, again based on the top quartile of herds. Therefore, a primary objective of the current study was to estimate the current national mean 6 week in-calf rate, 3 week submission rate and first service conception rate. This would allow some assessment of whether that target can be achieved and whether change had occurred since the study of Xu and Burton (2003) was conducted.

In seasonal-calving herds, reproductive performance is commonly assessed using both 6 week in-calf rate and the proportion of animals that fail to conceive by the end of the mating period (not in-calf rate) (McDougall 2006; Morton 2010). While the not in-calf rate is commonly used by herd owners, it is a less reliable measure for comparison of reproductive performance due to the wide between-herd variation in duration of mating and the inconsistency in the timing, reasons and extent of culling before final herd pregnancy diagnoses are performed. The 6 week in-calf rate has been used as it describes pregnancy rates for a typical artificial insemination period duration (42 days), and allows for approximately two oestrus cycles for most cows calving in advance of mating start date (MSD; first day of the mating period). This measure reflects the period of greatest variability in proportion pregnant between herds and is generally comparable between herds, as almost all herds breed for more than 42 days and very few cows are culled within this period reducing potential for selection bias. Hence it was selected as the main reproductive outcome for the current study. The 6 week in-calf rate is a product of two 'drivers' of reproductive performance, the proportion of animals submitted for insemination (submission and resubmission rate) and the success of each insemination (conception rate) (Macmillan 2002b, Morton 2010). Therefore, these outcomes are also reported. Measures of performance relative to each cow's calving date such as the calving to conception interval are unsuitable in seasonal-calving herds, as in this system, cows can conceive only from the calendar date for the MSD, irrespective of their calving date (Wapenaar*, et al.* 2008, Morton 2010).

The high herd-level variability in 6 week in-calf rate identified by Xu and Burton (2003) is likely to be due to differences in on-farm management of reproduction as well as differences between herds in distributions of cow-level factors. In the last twenty years, there has been a decline in dairy farm numbers by 16%, from 13,892 in 1999/2000 to 11,691 farms in 2010, and an increase in the mean herd size by 37% to 376 animals (Anonymous 2010-11). This has been accompanied by a trend towards corporate business enterprises amongst New Zealand dairy farms and it has been suggested that this may affect the way management decisions are made (Burke & Verkerk 2010). It has been suggested that larger herd sizes or shifts in responsibility can increase the risks of low efficacy of oestrus detection (Gordon 2011), low body condition score (McDougall 2006), and reduced animal welfare (Stafford & Gregory 2008). A range of risk factors, including oestrus detection and cow body condition score have been hypothesised to contribute to a large range in reproductive performance across New Zealand dairy herds (Verkerk 2003). For delivery of effective extension programmes to the New Zealand dairy industry, a better understanding of associations between socio-demographic variables and reproductive performance under New Zealand conditions is essential.

The objectives of this study were to:

1. Describe the reproductive performance of a selection of New Zealand dairy herds in 2009/10 and 2010/11, and
2. explore associations between a number of biophysical and socio-demographic herd-level variables and herd-level reproductive outcomes.

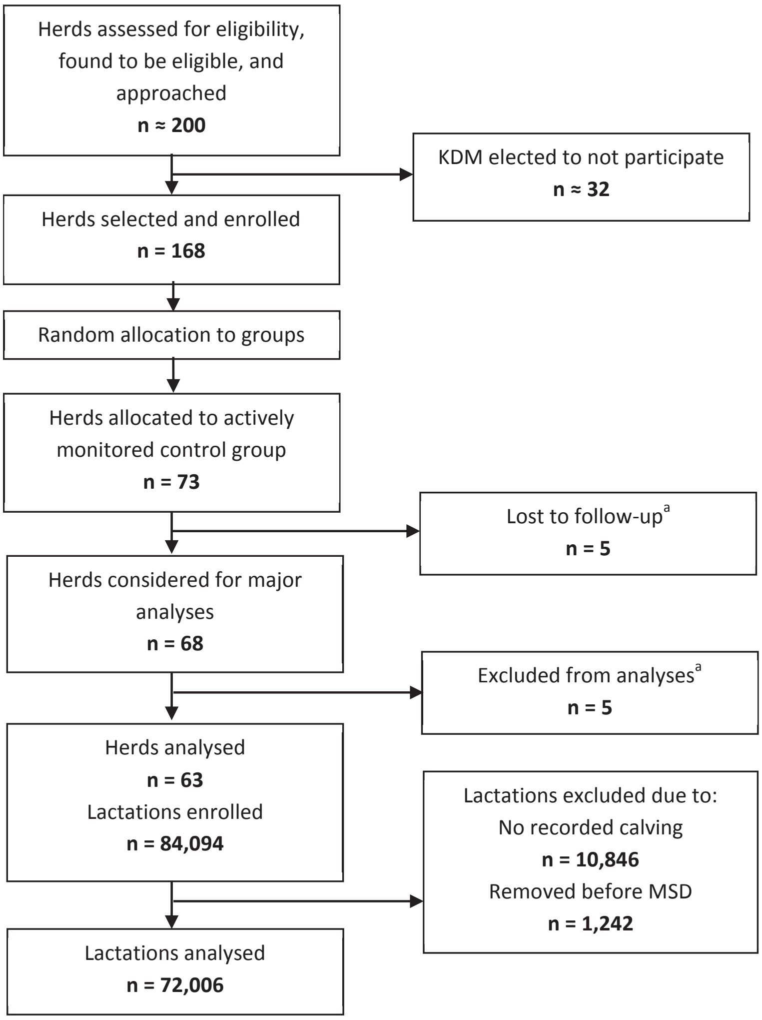
3.3. Materials and methods

3.3.1. *Overview of the study*

This study is the second of a series involving dairy herds from four regions across New Zealand, collectively called the National Herd Fertility Study (Chapter 2). The four regions were purposively chosen to represent a diverse cross-section of the dairy industry, i.e. the Waikato and Taranaki regions in the North Island and north Canterbury and south Canterbury regions in the South Island. The National Herd Fertility Study was a herd-level, randomised controlled trial conducted between May 2009 and June 2011. Dairy herds were ranked by preceding years 6 week in calf rate then randomly allocated within sequential pairs or triplets of herds to one of two control groups or an intervention group (Chapter 2). One control group received active on-farm monitoring and reproductive performance of this group is reported in this current study. A second control group had only passive data collection and the intervention group participated in a reproductive extension programme aimed at improving their herd's reproductive performance. Reproductive performance of herds in these latter two groups is not reported in the current study.

3.3.2. *Herd selection (enrolment process)*

Criteria for study herd enrolment have been described in detail in Chapter 2. In summary, the KDM of each herd was required to: be a client of a regional coordinating veterinary practice, have a seasonal-calving herd, predominantly calving in spring (>90% of the herd calving annually between 01 June and 30 November), be likely to implement study protocol, keep good quality records, and to remain in the same location for the two years of the study. All KDMs considered eligible were approached, and could then self-select to participate in the study.



[a] Reasons for loss to follow up and exclusion discussed in text

Figure 3.1. Diagrammatic representation of the enrolment of herds and lactations to the actively monitored control group and analysed for the 2009/10 and 2010/11 study-years in the New Zealand National Herd Fertility Study

3.3.3. *Data management process*

Once enrolled, permission to access data within the New Zealand Dairy Core Database (Livestock Improvement Corporation) was granted by each KDM for the duration of the study. The data included herd-, cow- and cow-event level information. Each herd and cow was identified using unique participant codes and animal keys, respectively. The data were imported into a relational database created using structured query language format (SQL: Microsoft SQL Server Management Studio 2008. Seattle, WA). The alphanumeric lifetime identification number of the animal allowed events to be correctly assigned to each animal. The data structure also allowed animal movement between multiple herds within the study to be identified.

Pregnancy diagnoses and additional on-farm measures not captured by the on-farm software, and hence not in the New Zealand Dairy Core Database, were entered into the National Herd Fertility Study database by matching the herd-level management ear tag number or unique alphanumeric lifetime identification number to an identical animal identification present in the database on the date of the farm visit. Where no match could be found, the herd owner/manager was approached to validate the discrepancy and the data were amended where possible. Data were edited and then used to create herd-year and lactation-level tables in the database.

Table 3.1. Description of lactation-level and herd-level outcome variables derived from lactation-level variables used in the National Herd Fertility Study

Reproductive measure	Description
Lactation-level	
In-calf by week six	Conceived during the first 42 days of the mating period
Submitted by week three	Served at least once during the first 21 days of the mating period
Conceived to first service[a]	Conceived to first insemination for the lactation (i.e. where the conception date equalled the first service date)
Herd-level	
6 week in-calf rate	Proportion of lactations analysed in which the cow was pregnant by day 42 after MSD
3 week submission rate	Proportion of lactations analysed in which the cow was served at least once by day 21 of the mating period
First service conception rate	The proportion of first services[a] that resulted in conception

[a] Only lactations analysed where the first service was by artificial inseminations were used to derive this measure

3.3.4. *Herd-year definition*

The start of a herd-year was defined using the mating start date (MSD) for each herd minus 130 days. The end of a herd-year was defined as the MSD of the subsequent year minus 130 days. The MSD was taken as the first date in the year with inseminations that was followed by inseminations on two or more of the subsequent 5 days.

3.3.5. *Lactation selection*

Lactation was eligible for inclusion if there was a calving event between the start of the herd-year (MSD – 130 days) and 59 days after the MSD. This excluded animals mated for the first time at 12 to 15 months of age (i.e. yearlings bred in that year) and animals without recorded parturitions in that herd-year (n = 124,037). Thus, cows were excluded if they had been retained in the herd despite not conceiving during the previous lactation (i.e. carry-over cows; n = 16,270). Animals also had to be present in the herd at the MSD; thus cows that had calved and were culled in the period between their calving and MSD were not included in analyses (N = 1,864). Animals that were present at MSD but removed before pregnancy diagnosis were included in analyses.

Cows were considered exposed to the risk of conception for the period from MSD to the end of the mating period for that herd-year. The end of the mating period for each herd-year was specified by the later date of either the last recorded artificial insemination (where no natural mating period followed the artificial insemination period) or, more frequently, by the date that bulls were withdrawn from the herd. This date was supplied by the KDM on an annual basis and validated against latest pregnancy diagnosis.

The process for the enrolment of herds and lactations in the New Zealand National Herd Fertility Study and allocated to the actively monitored control group is shown in Figure 3.1. As shown in this figure, five allocated herds were subsequently lost to follow-up before on-farm measures were undertaken; KDMs in two herds were unwilling to comply with study protocol while in the remaining three herds, KDMs were unable to adequately undertake the protocol. A further five allocated herds were subsequently excluded from analyses due to incomplete data or management changes during the study.

3.3.6. *Conception date determination*

Fetal age and hence conception date were determined by experienced veterinarians using transrectal ultrasonographic examination of the reproductive tract in both herd-years of the study (2009/10 and 2010/11). The most accurate estimates of fetal age are achieved when pregnancy testing occurs between 35 and 90 days post-insemination (Matthews & Morton 2012). Estimates of stage of gestation can be moderately accurate outside this time range but accuracy of fetal ageing diminishes over 90 days post insemination and sensitivity and specificity for detection of pregnancy and non-pregnancy respectively is reduced in cows at earlier stages of pregnancy (McDougall*, et al.* 2005). In order to accurately determine the stage of pregnancy where matings occurred in the first 42 days of the mating period, pregnancy diagnosis was mandated to occur at 86 days (±7 days) after the MSD. Thus, at pregnancy diagnosis, fetuses were no greater than 93 days old and pregnancies to services within the first 42 days of mating could be accurately diagnosed.

Veterinarians were asked to nominate lower and upper gestation ages (diagnostic limits) between which they were confident that they could diagnose fetal age. Where a mating occurred less than the lower gestational age limit, the cow was defined as 'not diagnosed pregnant' (NDP) and not classified as having conceived. For example, if a veterinarian nominated 35 days as a lower diagnostic limit, a diagnosed pregnancy aged ≤34 days was classified as NDP rather than being assigned a conception date. Where pregnancy stage was diagnosed as being greater than the veterinarian's upper diagnostic limit, a diagnosis of 'pregnant' was assigned a fetal age defined as between the upper diagnostic limit and the maximum possible number of days pregnant (i.e. MSD). As the study mandated that the first round of pregnancy diagnosis be within the veterinarian's upper diagnostic limit, all animals diagnosed as pregnant to greater than the veterinarians lower limit at the herd's first pregnancy diagnosis visit had conception dates assigned.

To reduce measurement bias, veterinarians were asked to diagnose fetal age while blinded to each cow's mating history. They then aligned their estimated fetal age with an insemination date if one was available. If a cow had multiple pregnancy diagnoses in the same lactation with different conception dates and the conception date from the second pregnancy diagnosis was within 14 days of the first conception date, the date from the first pregnancy diagnosis was retained. If the second date was more than 14 days after the first date, it was considered a 'new pregnancy event' (i.e. due to either measurement error at first pregnancy diagnosis or pregnancy loss and reconception, respectively). Where a cow had a new pregnancy event, the conception date from the second pregnancy diagnosis was used in analyses. To identify conceptions late in the mating period, and to identify animals that were not pregnant at the end of the mating period ('empty'), a second pregnancy diagnosis visit and, where the duration of the mating periods was >16 weeks, a third visit was completed. Cows not diagnosed pregnant at previous visits were examined at these visits but cows previously diagnosed pregnant were not re-examined except where the KDM suspected fetal loss had occurred. The final pregnancy diagnosis visit date was planned such that it was at a greater interval after the end of the mating period than the veterinarian's minimum diagnostic limit. All animals not diagnosed pregnant at any stage and either not detectably pregnant or not examined at the final pregnancy diagnosis visit for the herd-year were classified as not having conceived during the mating period. Times of second and third pregnancy diagnosis visits were not mandated for the study.

3.3.7. *Dependent/outcome variables*

The outcome variables were the 6 week in-calf rate, the 3 week submission rate and the first service conception rate (Figure 3.1). Natural first services were excluded for this outcome as the reliability of recording natural matings was uncertain.

3.3.8. *Independent variables*

Independent variables were selected using a causal diagram developed from a literature search and discussion with experienced reproduction-focused researchers. This diagram was used to identify plausible predictors of the three reproductive outcomes (Tables 3.3, 3.4), intervening variables (a variable that is caused by the independent variable and can cause the dependent variable) and potential confounders (extraneous variables that correlate with both the independent and the dependent variable). Lactation-level variables were derived for descriptive purposes from data extracted from the New Zealand Dairy Core Database. Herd-level biophysical and socio-demographic data for the herd and KDM were collected during interviews conducted at the start of the study (May to June 2009). Herd-level independent variables used in univariate and multivariable analyses were described in Chapter 2.

3.3.9. *Lactation-level variables*

Individual cow ages were calculated in years using the interval from cow birth date to the herd's MSD for that lactation divided by 365.25. Ages were categorised as 2, 3, 4-8 or >8 years as the relationship between age and reproductive outcomes is curvilinear (Grohn & Rajala-Schultz 2000, Morton 2004).

The New Zealand Dairy Core Database records each cow's breed as a summary of 16 breed components contributed by the previous two generations of the cow's lineage. If a cow had >12/16ths of either the Friesian or Jersey breed, they were defined as Friesian and Jersey, respectively. All other cows were described as 'crossbreeds'. The proportion of cows that had >12/16ths of breeds other than Friesian or Jersey was negligible and so these cows were pooled with crossbreds. The predominant breed of each herd was summarised from the individual cow breed using similar rules; where a herd had >12/16ths of either Friesian or Jersey cows, they were designated a pure-bred Friesian or Jersey herd, respectively. All other herds were considered crossbred herds.

Recorded uses of hormonal treatments were obtained from farm records. Induction of premature parturition ('calving induction') was defined on the basis of a record of administration of corticosteroids within several weeks before calving. Cows were defined as having been diagnosed with mastitis where there was a record of a pharmacological treatment for mastitis, such as intra-mammary antibiotic therapy, and where this record was between calving and the end of mating. Types and durations of these treatments were disregarded. Where individual cow milk production recording ('herd testing') had occurred, milk yield (L/cow/day), milk protein and fat percentage and milksolids (kg/cow/day), at the first herd test for the herd in that year were summarised.

3.3.10. *Herd-year level variables*

The herd size (i.e. number of lactating cows) was defined as the number of lactations analysed for the herd-year as described above. Effect of herd size was analysed as a change in units of one standard deviation of the herd sizes of all herd-years pooled, (1 SD = 309 animals). The area of each farm used for pasture production for the herd (effective farm area (hectares)) was provided by the KDM at the initial interview, with adjustment for annual changes, where appropriate.

3.3.11. *Herd-level variables*

Socio-demographic variables of the KDM were age, occupation, undertaking of any post-school tertiary training or qualifications and years of farming experience. These were assessed once at the start of the study, during baseline interviews conducted with the KDM during May and June 2009. Key decision makers were also asked to identify which of five herd production system categories best described their herd: 1 = no imported feed fed to lactating or non-lactating (dry) cows; 2 = 4–14% of the total nutritional requirement was imported feed and fed to lactating cows, and dry cows grazed off-farm; 3 = 10–20% was imported feed fed to dry cows and to lactating cows at the end of the year to extend lactation; 4 = 20–30% imported feed fed to dry cows and to lactating cows at both the beginning and end of the year to extend lactation; 5 = 25–30% imported feed used throughout the year (Anonymous 2009). Due to small numbers of herds in some categories within regions, production systems were collapsed into two levels; low input or extensive (categories 1 to 3) and high input or intensive systems (categories 4 and 5; table 3.2). Farm business structure was categorised as either family owned or non-family owned (Table 3.2).

An estimate of the 6 week in-calf rate in the herd-year prior to enrolment (2008/09) was used to describe reproductive performance of herds prior to study start date. This estimate was derived by applying the InCalf Fertility Focus Report algorithm; 6-week in-calf rate is estimated based on herd calving pattern, 3-week submission rate and herd non-return rate using an algorithm developed with data from Australian Dairy Herd Fertility Project (Morton 2004). As not all herds had undertaken appropriately timed whole-herd pregnancy testing in the lactation preceding the study, these 6 week in-calf rate estimates were used for all herds.

3.3.12. *Statistical analysis*

Data were transferred to Stata 12 (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP.). For each herd-year, continuous variables were described using means, standard deviations and range; categorical variables were described using percentages.

Correlation between covariates was assessed using Pearson’s correlation coefficients. For example, herd size, farm size and total full time staff equivalents (FTE) were highly correlated (r = 0.92 for herd size by farm size, r = 0.77 herd size by FTE and r = 0.82 for farm size by FTE). In this case the most plausible causal variable was herd size and the other variables were not analysed.

The herd-year was the unit of analysis for all models. Reproductive outcome variables of 6 week in-calf rate, 3 week submission rate and first service conception rate were analysed as proportions using a generalised linear model fitted for a binomial distribution with a logit link to estimate the change in odds associated with one unit change in the value of the covariate. Standard errors that accounted for clustering of observations within herd were used to account for lack of independence between herd observations (Peters*, et al.* 2003). Univariate associations between ten socio-demographic and biophysical independent variables selected in a previous analysis of these data in Chapter 2 and each outcome variable were evaluated. All univariate associations were reported. All ten independent variables were then entered into separate multivariable models for each outcome variable, and models reduced in a backwards elimination fashion, with variables sequentially excluded in descending order based on p-value until $p<0.05$ for all remaining variables. Once excluded, variables were not eligible for re-inclusion in the model. Interaction terms were assessed following backwards elimination where biologically plausible. Region and study-year were forced into all univariate and multivariable models based on an *a priori* decision, to account for expected clustering of herds within region, and for any effects of study-year.

3.4. Results

Data from 72,006 lactations contributed by 45,363 cows from 63 herds over two herd-years (2009/10 and 2010/11) (126 herd-years in total) were used for the final analysis.

Descriptive analysis

3.4.1. *Outcome variables*

The mean 6 week in-calf rate for the 126 herd-years was 66.7% (SD 8.0) (65.4% in 2009; 67.7% in 2010) with a range of 46.0-86.0%. The mean 3 week submission rate was 81.8% (SD 9.0) (81.2% in 2009; 82.3% in 2010) with a range of 45.0-95.0% and the mean first service conception rate was 48.4% (SD 8.2) (48.2% in 2009; 48.5% in 2010) with a range of 25.0-71.0% (Figure 3.2).

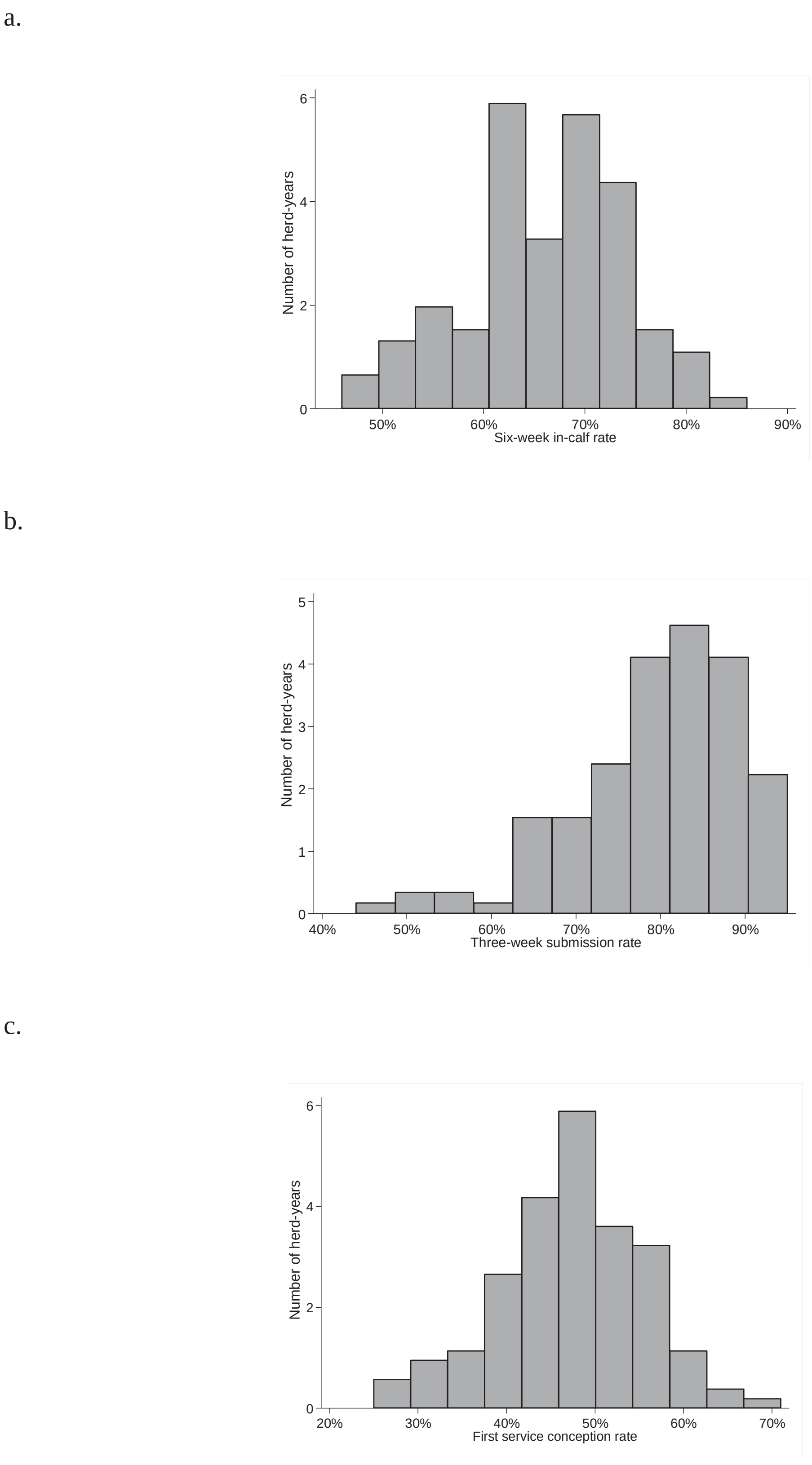


Figure 3.2 a-c. Distributions of 6 week in-calf rates (a), 3 week submission rates (b) and first service conception rates (c) for herds within the New Zealand National Herd Fertility Study that were allocated to the actively monitored control group, for the 2009/10 and 2010/11 study-years pooled (n=126 herd-years)

3.4.2. *Lactation-level variables:*

The mean age of cows at MSD was 4.8 (SD 2.5) years. Of the lactations, 37,494 (52.1%) were in crossbred cows, 26,450 (36.7%) were in Friesians and in 8,062 (11.2%) Jerseys. Over both study-years, 4,093 lactations (5.7%) were recorded as commencing with an induced calving, while 6,373 lactations (8.9%) had hormonal treatment for anoestrus recorded. Mastitis was recorded in 8,396 lactations (11.7%) and lameness recorded in 2,679 lactations (3.7%).

Milk production data was available for 59,381 (82.4%) lactations (26,910 lactations in 2009/10 and 32,471 in 2010/11). The mean total production volume recorded at the first herd test was 19.1 L/cow/day, containing 3.8% (SD 0.5) milk protein and 4.6% (SD 1.1) milk fat. At this first herd testing visit, tested cows were, on average, 60.9 days (SD 47) post-parturition.

A total of 14,082 cows were removed across the two study-years of which culling accounted for 67.0% , sales 24.0%, deaths 8.7% and moving to another herd 0.2%.

3.4.3. *Herd- and herd-year-level variables:*

Summary statistics of independent variables are presented in Tables 3.3 and 3.4.

More herds used intensive production system in the South compared with the North Island (Table 3.2) as has been reported previously (Anonymous 2009).

Table 3.2. Distribution of 63 seasonal-calving, pasture-based dairy herds from four regions in New Zealand for the 2009/10 and 2010/11 herd-years pooled by region and production system category

Production system	**Region**			
	Waikato	**Taranaki**	**N. Canterbury**	**S. Canterbury**
Extensive (1-3)[a]	9	11	4	3
Intensive (4-5)[a]	7	5	13	11

[a] Production systems were defined as: 1 = no imported feed fed to lactating or non-lactating (dry) cows; 2 = 4–14% imported feed fed to lactating cows, and dry cows grazed off-farm; 3 = 10–20% imported feed fed to dry cows and to lactating cows at the end of the year to extend lactation; 4 = 20–30% imported feed fed to dry cows and to lactating cows at both the beginning and end of the year to extend lactation; 5 = 25–30% imported feed used throughout the year (Anonymous 2009).

The percentage of calvings that were by two year old animals (i.e. animals first entering the milking herd) (replacement rate) varied between herd-years from 4 to 34% with a mean of 20.9% (SD 4.9) (Table 3.3). The mean MSDs over all study herds were 20 and 21 October for the 2009 and 2010 herd-years, respectively. This varied from 8 October in 2009 and 2010 in the Waikato region to 23 October in 2009 and 2010 in the South Canterbury region. The mean total duration of the mating period (i.e. the sum of the artificial insemination and natural mating periods), was 94 days (SD 14 days; range 58 - 128), varying from 89 days in the South Canterbury region to 100 days in the North

Canterbury region. The mean duration of the artificial insemination period, was 42 days (SD 12 days; range 23 - 99 days), varying from 37 days in the Waikato to 45 days in the south Canterbury *region.*

Table 3.3. Summary statistics for herd-year level continuous biophysical and socio-demographic variables from 63 seasonal-calving, pasture-based dairy herds from four regions in New Zealand for the 2009/10 and 2010/11 herd-years pooled

Variable	Mean	Std. Dev.
Size of herd (number of lactations analysed for herd-year)	559	309
Effective farm area (ha)[a]	161	75
Cows/ha	3.35	0.75
Full-time staff equivalents (FTE)	3.28	1.38
Cows/FTE	167.4	58.09
Mean herd cow age (years)	4.82	0.36
Cow age category (proportion of herd)		
2 years old	0.21	0.04
3 years old	0.17	0.04
4 - 8 years old	0.52	0.06
>8 years old	0.10	0.04
Mean milk volume (L/cow/day)[b]	19.05	6.92
Mean milksolids (kg/cow/day)[b]	1.85	0.52
Mean milk protein (%)	3.75	0.48
Mean milk fat (%)	4.60	1.11
KDM dairy farming (years)[c]	20	9

[a] Effective farm was pasture land used for dairy grazing.

[b] Mean milk volume and milksolids recorded at first herd test after calving

[c] Number of years that the KDM had been dairy farming at the start of the study

Table 3.4. Summary statistics for herd-level categorical socio-demographic and biophysical variables from 63 seasonal-calving, pasture-based dairy herds from four regions in New Zealand over the 2009/10 and 2010/11 herd-years

Variable	Category	n	Percentage
Key decision maker			
Age category (years at start of study)	20-29	6	10
	30-39	16	25
	40-49	24	38
	≥50	17	27
Occupation[a]	Owner operator	40	63
	Higher order sharemilker	10	16
	Lower order sharemilker	7	11
	Farm manager	6	10
Post school education	No	21	33
	Yes	42	67
Farm			
Region	Waikato	16	25
	Taranaki	16	25
	North Canterbury	17	27
	South Canterbury	14	22
Business structure	Family owned	51	81
	Not family owned	12	19
Production system[b]	1	4	6
	2	6	10
	3	17	27
	4	21	33
	5	15	24
Herd			
Predominant breed[c]	Friesian	7	11
	Crossbreed	53	84
	Jersey	3	5

[a] Higher-order sharemilkers were those that received >35% of farm income; lower-order sharemilkers were those that received ≤35% of farm income

[b] Production systems were defined as: 1 = no imported feed fed to lactating or non-lactating (dry) cows; 2 = 4–14% imported feed fed to lactating cows, and dry cows grazed off-farm; 3 = 10–20% imported feed fed to dry cows and to lactating cows at the end of the year to extend lactation; 4 = 20–30% imported feed fed to dry cows and to lactating cows at both the beginning and end of the year to extend lactation; 5 = 25–30% imported feed used throughout the year (Anonymous 2009).

[c] Predominant breed was defined where ≥75% of the herd comprised of animals with ≥13/16 of one of Friesian or Jersey components

3.4.4. *Univariate analysis*

The herd's previous 6 week in-calf rate (i.e. for 2008/09, before herds were enrolled) was positively associated with the 6 week in-calf rate, the 3 week submission rate and the first service conception rate (all p<0.01). There were no other significant associations between any of the remaining independent herd-level socio-demographic and biophysical variables assessed and either 6 week in-calf rate or 3 week submission rate (p≥0.15; Table 3.5). On univariate analyses, first service conception rate was higher for extensive compared with intensive production systems (p=0.05), in family owned than non-family owned businesses (p=0.07) and in herds where the predominant breed was Jersey (p=0.09) (Table 3.5).

Table 3.5. Univariate models of associations between herd-level independent variables and 6 week in-calf rate, 3 week submission rate and first service conception rate from 63 seasonal-calving, pasture-based dairy herds from four regions in New Zealand over the 2009/10 and 2010/11 herd-years.

	6 week in-calf rate			3 week submission rate			First service conception rate		
	OR	95% CI	p value	OR	95% CI	p value	OR	95% CI	p value
KDM									
KDM age category									
20-29	Ref		0.83	Ref.		0.41	Ref.		0.73
30-39	1.04	(0.8-1.35)		1.13	(0.73-1.74)		1.07	(0.88-1.3)	
40-49	1.09	(0.87-1.36)		1.31	(0.9-1.9)		1.09	(0.93-1.28)	
>=50	0.99	(0.76-1.29)		1.06	(0.66-1.72)		1.04	(0.84-1.28)	
Occupation									
Owner operator	Ref		0.76	Ref.		0.39	Ref.		0.73
Higher-order sharemilker	1.15	(0.83-1.6)		0.96	(0.67-1.37)		1.10	(0.85-1.43)	
Lower-order sharemilker	1.05	(0.82-1.34)		0.98	(0.63-1.53)		0.92	(0.73-1.16)	
Farm manager	1.06	(0.9-1.25)		1.36	(0.93-1.98)		0.95	(0.79-1.14)	
Post-school education			0.15						
No	Ref			Ref.		0.30	Ref.		0.12
Yes	1.14	(0.95-1.37)		1.17	(0.87-1.56)		1.14	(0.97-1.35)	
Years farming experience	0.99	(0.98-1)	0.17	0.99	(0.97-1.01)	0.28	1.00	(0.99-1)	0.36
Farm									
Production system[a]									
1-2	Ref		0.17	Ref.		0.51	Ref.		0.05
3-5	0.87	(0.72-1.06)		0.89	(0.64-1.25)		0.84	(0.71-1)	
Farm business model									
Family owned			0.46	Ref.		0.61	Ref.		0.07
Non-family owned	0.92	(0.74-1.14)		1.08	(0.8-1.47)		0.85	(0.72-1.01)	
Herd									
Herd size (SD)[b]	1.00	(0.9-1.11)	0.94	1.08	(0.94-1.24)	0.29	0.94	(0.87-1.03)	0.17
Mean herd age (years)	0.95	(0.74-1.22)	0.67	0.85	(0.6-1.22)	0.38	0.89	(0.73-1.1)	0.28
Predominant breed									
Friesian	Ref		0.85	Ref.		0.39	Ref.		0.09
Crossbreed	1.08	(0.81-1.44)		1.02	(0.74-1.41)		1.06	(0.89-1.28)	
Jersey	1.12	(0.74-1.71)		1.33	(0.84-2.12)		1.24	(1-1.55)	
Previous 6wk in-calf rate									
0-25%	Ref		<0.01	Ref.		<0.01	Ref.		<0.01
26-50%	1.02	(0.86-1.22)		1.05	(0.81-1.36)		1.03	(0.87-1.21)	
51-75%	1.25	(1.01-1.55)		1.56	(1.15-2.1)		1.19	(0.99-1.42)	
76-100%	1.37	(1.15-1.64)		1.91	(1.45-2.51)		1.37	(1.19-1.57)	

[a] Categorised as extensive (levels 1 to 3) or intensive (levels 4 and 5) using predefined production systems: 1 = no imported feed fed to lactating or non-lactating (dry) cows; 2 = 4–14% imported feed fed to lactating cows, and dry cows grazed off-farm; 3 = 10–20% imported feed fed to dry cows and to lactating cows at the end of the year to extend lactation; 4 = 20–30% imported feed fed to dry cows and to lactating cows at both the beginning and end of the year to extend lactation; 5 = 25–30% imported feed used throughout the year (Anonymous 2009).

[b] Herd size analysed in units of the standard deviation of the mean herd size: 309 animals.

KDM = key decision maker; Ref = reference category

3.4.5. *Multivariable analysis*

Similar associations were evident in the three multivariable models (Tables 3.6-8). Region and study-year were forced into all models based on an *a priori* decision, and were not significantly associated with any outcome ($p \geq 0.05$). Pre-enrolment 6 week in-calf rate was associated with all three outcome variables, with greater odds for each increasing quartile of previous performance ($p < 0.001$). For each outcome, intensive production systems had poorer performance than extensive systems (OR = 0.91, 0.82 and 0.82 for 6 week in-calf rate, 3 week submission rate and first service conception rate, respectively). However, there was a significant interaction between production system and region for each outcome ($p < 0.05$), with better odds of improved reproductive performance in intensively managed herds in north Canterbury than would be expected based on the combined effects of a) region in extensively managed systems and b) intensive relative to extensive management in Waikato (Figure 3.3 and Table 3.6-8). In other words, there was evidence that intensively managed herds in north Canterbury were at least partly overcoming adverse effects of being a) in north Canterbury and b) intensively managed. Similarly, intensively managed herds in Taranaki and south Canterbury had lower odds of improved 6 week in-calf rate than expected, providing evidence that they were experiencing greater difficulties in achieving high herd reproductive performance after accounting for the beneficial effects of their regions and adverse effects of being intensively managed.

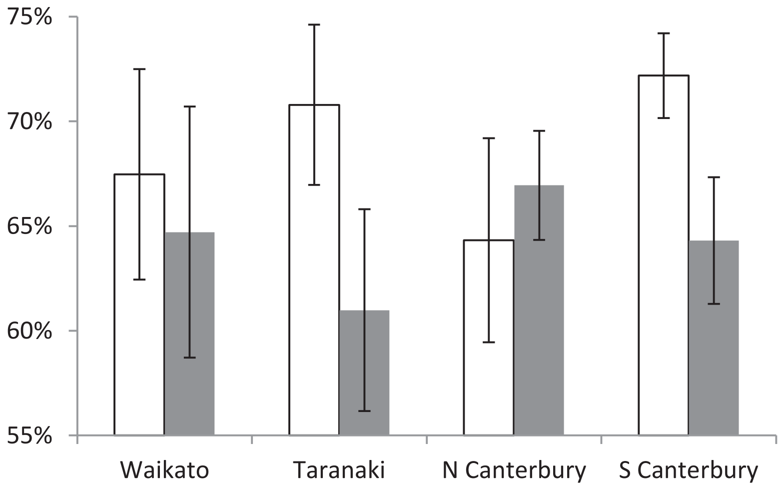


Figure 3.3. Marginal mean estimates (with 95% CIs) of 6 week in-calf rates of seasonal-calving, pasture-based dairy herds in four regions of New Zealand for 2009/10 and 2010/11, accounting for the interaction of extensive (white bar) and intensive (grey bar) production system by region.

Occupation of the KDM and predominant breed of the herd were associated with 3 week submission rate. This outcome was higher for farm managers than owner operators (OR=1.65) and where the predominant breed was Jersey compared with Friesian or crossbred (Table 3.7).

Table 3.6. Multivariable model of associations of herd-level independent variables with 6 week in-calf rate from 63 seasonal-calving, pasture-based dairy herds from four regions in New Zealand over the 2009/10 and 2010/11 herd-years.

6 week in-calf rate		OR	95% CI	p value
Study-year				
	2009/10	Ref.		0.10
	2010/11	1.06	(0.99 - 1.15)	
Region in extensively managed herds				
	Waikato	Ref.		0.28
	Taranaki	1.13	(0.86 - 1.47)	
	North Canterbury	0.82	(0.62 - 1.07)	
	South Canterbury	1.20	(0.96 - 1.49)	
Production system[a] in Waikato (reference region)				
	Extensive (1 to 3)	Ref.		0.02
	Intensive (4 and 5)	0.91	(0.67 - 1.24)	
Region*production system[b]				
	Waikato*Intensive	Ref.		<0.01
	Taranaki*Intensive	0.73	(0.48 - 1.10)	
	North Canterbury*Intensive	1.34	(0.92 - 1.95)	
	South Canterbury* Intensive	0.81	(0.58 - 1.13)	
Previous 6 week in-calf rate				
	0-25%	Ref.		<0.01
	26-50%	1.08	(0.92 - 1.28)	
	51-75%	1.33	(1.08 - 1.62)	
	76-100%	1.40	(1.16 - 1.70)	

[a] Categorised as extensive (levels 1 to 3) or intensive (levels 4 and 5) using predefined production systems: 1 = no imported feed fed to lactating or non-lactating (dry) cows; 2 = 4–14% imported feed fed to lactating cows, and dry cows grazed off-farm; 3 = 10–20% imported feed fed to dry cows and to lactating cows at the end of the year to extend lactation; 4 = 20–30% imported feed fed to dry cows and to lactating cows at both the beginning and end of the year to extend lactation; 5 = 25–30% imported feed used throughout the year (Anonymous 2009).

[b] These odds ratios estimate the 'extra' odds ratio on a multiplicative scale for the combination over that expected based on the combined effects of a) region in extensively managed systems and b) intensive relative to extensive management in Waikato. The * denotes interaction term between two variables

Table 3.7. Multivariable model of associations of herd-level independent variables with 3 week submission rate from 63 seasonal-calving, pasture-based dairy herds from four regions in New Zealand over the 2009/10 and 2010/11 herd-years.

3 week submission rate	OR	95% CI	p value
Study-year			
2009/10	Ref.		0.38
2010/11	1.07	(0.92 - 1.26)	
Region in extensively managed herds			
Waikato	Ref.		0.30
Taranaki	0.96	(0.68 - 1.35)	
North Canterbury	0.81	(0.67 – 1.07)	
South Canterbury	0.93	(0.60 - 1.59)	
Production system[a] in Waikato			
Extensive (1 to 3)	Ref.		0.15
Intensive (4 and 5)	0.82	(0.46 - 1.36)	
Region*production system[b]			
Waikato*Intensive	Ref.		0.04
Taranaki*Intensive	0.71	(0.43 - 1.17)	
North Canterbury*Intensive	1.42	(0.95 - 2.14)	
South Canterbury* Intensive	1.06	(0.61 - 1.83)	
KDM occupation			
Owner operator	Ref.		<0.01
Sharemilker	0.85	(0.69 - 1.06)	
Farm manager	1.65	(1.24 - 2.20)	
Herd predominant breed			
Friesian	Ref.		0.05
Crossbreed	0.99	(0.72 - 1.36)	
Jersey	1.25	(0.89 - 1.75)	
Previous 6 week in-calf rate			
0-25%	Ref.		<0.01
26-50%	1.10	(0.87 - 1.39)	
51-75%	1.84	(1.41 - 2.40)	
76-100%	2.09	(1.63 - 2.69)	

[a] Categorised as extensive (levels 1 to 3) or intensive (levels 4 and 5) using predefined production systems: 1 = no imported feed fed to lactating or non-lactating (dry) cows; 2 = 4–14% imported feed fed to lactating cows, and dry cows grazed off-farm; 3 = 10–20% imported feed fed to dry cows and to lactating cows at the end of the year to extend lactation; 4 = 20–30% imported feed fed to dry cows and to lactating cows at both the beginning and end of the year to extend lactation; 5 = 25–30% imported feed used throughout the year (Anonymous 2009).

[b] These odds ratios estimate the 'extra' odds ratio on a multiplicative scale for the combination over that expected based on the combined effects of a) region in extensively managed systems and b) intensive relative to extensive management in Waikato. The * denotes interaction term between two variables

Table 3.8. Multivariable model of associations of herd-level covariates with first service conception rate from 63 seasonal-calving, pasture-based dairy herds from four regions in New Zealand over the 2009/10 and 2010/11 herd-years.

First service conception rate	OR	95% CI	p value
Study-year			
2009/10	Ref.		0.54
2010/11	1.02	(0.96 - 1.09)	
Region in extensively managed herds			
Waikato	Ref.		0.45
Taranaki	1.12	(0.90 - 1.39)	
North Canterbury	0.71	(0.50 - 1.02)	
South Canterbury	1.02	(0.78 - 1.32)	
Production system[a] in Waikato			
Extensive (1 to 3)	Ref.		0.03
Intensive (4 and 5)	0.82	(0.64 - 1.05)	
Region*production system[b]			
Waikato*Intensive	Ref.		0.03
Taranaki*Intensive	0.79	(0.56 - 1.11)	
North Canterbury*Intensive	1.49	(0.98 - 2.27)	
South Canterbury* Intensive	1.03	(0.73 - 1.44)	
Previous 6 week in-calf rate			
0-25%	Ref.		<0.01
26-50%	1.07	(0.92 - 1.25)	
51-75%	1.24	(1.06 - 1.45)	
76-100%	1.38	(1.18 - 1.61)	

[a] Categorised as extensive (levels 1 to 3) or intensive (levels 4 and 5) using predefined production systems: 1 = no imported feed fed to lactating or non-lactating (dry) cows; 2 = 4–14% imported feed fed to lactating cows, and dry cows grazed off-farm; 3 = 10–20% imported feed fed to dry cows and to lactating cows at the end of the year to extend lactation; 4 = 20–30% imported feed fed to dry cows and to lactating cows at both the beginning and end of the year to extend lactation; 5 = 25–30% imported feed used throughout the year (Anonymous 2009).

[b] These odds ratios estimate the 'extra' odds ratio on a multiplicative scale for the combination over that expected based on the combined effects of a) region in extensively managed systems and b) intensive relative to extensive management in Waikato. The * denotes interaction term between two variables

3.5. Discussion

This study described aspects of reproductive performance of seasonal-calving, pasture-based dairy herds in New Zealand and examined the association between various socio-demographic attributes of KDM and biophysical attributes of their farms and herd reproductive performance. The key finding is that, based on the reproductive performance in the current study, achieving the industry 6-week in-calf rate target of 78% by 2016 at a national level appears unlikely unless there are substantial increases in both submission and conception rates. Improvements in conception rate have been shown to have greater impact on the reproductive performance of herds than increases in submission rate of the same magnitude; however, conception rate is reportedly more difficult to change than submission rate (Morton 2010). In the current study, the mean 6-week in-calf rate of the top quartile of herds was 76%.

Other key findings were the large range in reproductive performance between herds, and the observations that the strongest identified predictor of performance was previous 6 week in-calf rate, that herds providing a higher proportion of the cows' nutrient requirements from off-farm sources had poorer reproductive performance, and that Friesian dominant herds and those managed by farm owners (rather than managers) had poorer submission rates.

The mean 6 week in-calf rate of 67% in this study population was similar to the 68% reported for herds studied between 1998 and 2000 (Xu & Burton 2003). The mean 3 week submission rate of 81% in the current study was the same as that reported previously, but the mean conception rate to first service of 48% was lower than the 53% reported previously (Xu and Burton, 2003). The previous study did not mandate pregnancy diagnosis, as was the case in the current study. Instead pregnancy diagnoses were accepted where fetal ageing was undertaken otherwise subsequent calving data was used to predict conception. Where neither data were available, the cows were excluded from the analysis. This assumption likely resulted in overestimation of 6-week in-calf risks as animals that did not conceive to a mating in herds with poor heat detection sensitivity, especially in the latter part of AI mating would be falsely identified as pregnant and truly anoestrus cows that had been incorrectly mated also. The current study likely provided more accurate estimates of 6 week in-calf rates due to the mandated pregnancy diagnosis visits. However, these comparisons may be subject to selection bias as neither study selected herds randomly. Nevertheless, there is evidence that conception rates have been declining internationally for some years (Royal et al 2000; Lucy 2001). Conception rate is determined by many factors including numbers of days between calving and MSD, accuracy of oestrus detection, skill of the AI technicians, quality of the semen, and cow factors such as body condition score, energy balance and current disease (Rhodes*, et al.* 1998, Macmillan 2002b). It is beyond the scope of the current study to define all major factors affecting conception rate.

A further key finding is the large range in reproductive performance between herds, as has been reported previously (Xu & Burton 2003). This finding demonstrates that high levels of reproductive performance are achievable, and suggests that causal factors vary markedly between herds, being either herd-level factors or cow- and lactation-level variables that cluster by herd. If these factors can be identified and modified, improvements would be possible. In the current study, few associations were found between reproductive outcomes and socio-demographic or biophysical variables at the herd level, with the exception of previous 6 week in-calf rate. First service conception rate also varied with production system. This paradox suggests that the greatest variation is likely to be at cow-level or that the incorrect biophysical and socio-demographic variables were selected to explain the variation. Further work investigating cow or lactation-level factors is strongly suggested.

Selection bias for reproductive performance may have been introduced due to our herd selection criteria and subsequent exclusions. Regions were purposively selected to represent a diverse cross section of the dairy industry but mean herd sizes in study herds were larger than those reported in the New Zealand National Dairy Statistics (Anonymous 2010-11) in three of the regions; the mean herd size in the Waikato was 427 cows (mean herd size was 313 cows in National Dairy Statistics 2009/10), 340 cows in Taranaki (237 cows), 814 cows in north Canterbury (723 cows) and 707 cows in south Canterbury (743 cows). However, herd size was not associated with reproductive performance so means for reproductive performance were probably not biased due to larger sizes of study herds. We required that herds be likely to remain in the same location for the two years of the study and biased selection towards those KDMs considered likely to a) implement all study procedures and b) keep good quality records. In addition, some herds were excluded because of poor data collection. It is possible but perhaps unlikely that reproductive performance would differ between herds that were more likely to remain in the same location for the two study-years and herds likely to leave, however; it is plausible that these KDMs would be more likely to implement all study procedures well, keep good quality records and commit to improving reproductive performance in their herds. If so, it will be more difficult to reach the national performance target of an average 78% 6 week in-calf rate by the target date of 2016, than indicated by our results.

It is unlikely that lactation-level exclusion criteria introduced substantial selection bias. Where a calving was not recorded, the animal did not contribute to analyses for that herd-year, some herds had poor recording of calving data, thus leading to cows being inadvertently excluded from analysis on this basis. However, correspondence with the KDM was designed to ensure that all available calving data were collected, and unrecorded calvings would probably only affect the herd's 6 week in-calf rate substantially if underreporting was markedly greater for early or late calvings. This lactation selection requirement ensured that carry-over animals were not included in analyses; this was desirable as their physiology and management was unlikely to match that of recently calved animals within the herd. In this study, 82% of herds used commercial artificial inseminator contractors that completed electronic data entry of inseminations into the national data base and hence automated transfer to the National Herd Fertility Study. Consequently, artificial insemination data were probably, for the most part, reliable.

Imperfect specificity of pregnancy diagnosis (McDougall *et al.,* 2005) may have resulted in overestimation of 6 week in-calf rates. Cows diagnosed as pregnant at the first pregnancy examination were not generally examined again unless a return to oestrus behaviour had been observed by the farmer. Thus cows either incorrectly diagnosed as being pregnant or pregnant and suffered fetal loss following the first pregnancy test would likely not have been retested (unless detected in oestrus by the farmer) with the result that the 6 week in-calf rates may have overestimated. In contrast, any false negative result at the first pregnancy examination would not have markedly affected study outcomes as most of these pregnancies would have been detected at the subsequent examination. Veterinarians were asked to diagnose fetal age using the ultrasound image alone before aligning their estimation to the mating records. This would have helped reduce, but would not have completely removed measurement bias due to selection of incorrect conception dates for cows diagnosed pregnant.

Poor data recording occurs on many dairy farms, especially of lactation-level event data such as hormonal induction of parturition and anoestrus (Haile-Mariam *et al.,* 2007). Herd selection was biased towards KDMs considered likely to maintain good quality records, on-farm technician support was provided and comprehensive study guidelines to increase the level of reporting were distributed. During the data validation that occurred during the study, a further 14,001 lactation level events (mostly mastitis treatments, induced parturition and anoestrus treatments) that had not been entered into the electronic databases were identified and entered. Despite this, it is likely some degree of underreporting of events still occurred. If data for exposure variables were affected, this was probably non-differential; if so, the sizes of the effect of the affected variables would probably have been underestimated.

The association between all reproductive outcomes and previous 6 week in-calf rate was not unexpected. Previous lactation 6 week in-calf rate partly determines calving pattern, and may also influence herd age structure through indirect effects on culling and replacement rates. Calving pattern has been identified as a major risk factor for 6 week in-calf rate and reproductive performance is reduced in young and old cows (Grohn & Rajala-Schultz 2000, Morton 2004). This suggests that that rate of improvement in herd reproductive performance may be slow unless substantial changes in management occur resulting in duration of calving being reduced with a resultant increase in the average interval from calving to PSM. Conversely, improvements in reproductive performance that result in more compact calving patterns may result in consistent improvements.

In the multivariable analysis, extensive farm systems had higher reproductive performance compared with intensive systems. The mechanism for this is not clear. There are small negative phenotypic and genotypic relationships between milk yield and some measures of reproductive performance (LeBlanc 2010), and those farms importing a greater proportion of feed would have a higher per cow fed intake and hence higher milk production per cow. However, there was also a region by production system interaction whereby intensively managed herds in north Canterbury were at least partly overcoming adverse effects of being intensively managed, whereas intensively managed herds in Taranaki and south Canterbury were experiencing greater difficulties in achieving high herd reproductive performance after accounting for the beneficial effects of their regions and adverse effects of being intensively managed. This may reflect differences in managerial expertise in intensive feeding systems and hence variable impacts of such feeding on cow reproduction. South Island regions (north and south Canterbury) had a majority of herds under the intensive production system (76% and 78% respectively). Further work is needed to explain the difference in reproductive performance between the intensive production system regions.

Occupation of the KDM and the predominant breed of the herd were associated with 3 week submission rate. Where the KDM was a farm manager, there were increased odds of a greater submission rate. It is possible that motivation to detect and inseminate cows may vary between occupation types. For example, managers may have reproductive performance measures included in their employment contracts or have a daily target for matings and fulfil this with less regard to accuracy than owner operators. The finding of increased odds of higher submission rates for Jersey than Friesian herds is in agreement with previous reports of higher reproductive performance in the Jersey breed, due, in part, to easier detection of oestrus behaviour (Clark *et al.,* 2007).

In summary, this study has provided the most precise estimate of the reproductive performance of dairy herds in New Zealand to date. The New Zealand dairy industry has set the target of a national mean 6 week in-calf rate of 78%, with minimal hormonal intervention by 2016. Reaching this target within this time period appears unlikely unless substantial change in submission and conception rates occurs. However the large differences between herds indicate that better reproductive performance is currently possible in many herds. Further investigation of on-farm management practices for known risk factors for detection of oestrus and successful conception is required. However, it may not be necessary to tailor extension strategies for improving reproductive performance to specific socio-demographic or biophysical factors such as KDM age, herd-size or region. Previous 6 week in-calf rate was the strongest identified predictor of current reproductive performance suggesting that rate of improvement would most likely be slow within management systems currently used in New Zealand dairy herds unless substantial changes in management decisions are introduced. However where improvement in reproductive performance is brought about, the slow change in these results also suggest that reproductive performance could remain improved for some years.

CHAPTER 4

A randomised controlled study to assess the effects of an extension programme (InCalf Farmer Action Group) on the reproductive performance of seasonal calving, pasture-based dairy herds

Tom S. Brownlie, John M. Morton, Cord Heuer and Scott McDougall

4.1. Abstract

This study aimed to quantify the effect of participation by dairy farmers in an extension programme designed to improve reproductive performance on the proportion of cows in their herds becoming pregnant during the first 6 weeks of the seasonal breeding program (6 week in-calf rate), to assess possible interactions between treatment and various biophysical and socio-demographic factors, and to evaluate the effect of being involved in an actively monitored control group on 6 week in-calf rate. Herds from four dairy regions of New Zealand were blocked by region, ranked by previous 6 week in-calf rate and then assigned to treatment (n = 73 herds), an actively monitored control group (n = 73 herds) or a passively monitored control group (n = 22). Treatment consisted of participation in a group-based year-long extension programme. Reproductive performance was assessed in that year (2009/10) and the following year (2010/11). The key decision makers (KDM) of treatment and actively monitored control groups were interviewed before the commencement of the study to capture biophysical and socio-demographic data. Herds in these two groups also had dated ultrasonographic pregnancy diagnoses undertaken at strategic times so that accurate estimates of the 6 week in-calf rates could be calculated in each of the two study-years. Cow demographic data were downloaded from the National Dairy Database. Multivariable modelling was used to determine the effect of treatment on 6 week in-calf rate, adjusting for design factors (study-year and region). We estimated that 6 week in-calf rate (risk difference) increased by 2.0% (95% CI 0.0% to 3.9%) as a result of participation in the extension programme (p = 0.05). No significant interactions were found between treatment and any of region, study-year, or various biophysical and socio-

demographic variables on the 6 week in-calf rate. There was no difference in the 6 week in-calf rate between the actively- and passively-monitored control groups. We conclude that enrolment in the extension program improves the 6 week in-calf rate, and that the treatment effect is not modified substantially by region, study-year or any of the biophysical and socio-demographic variables assessed. Thus treatment effects are broadly consistent over a range of farm systems, geographic regions and KDM types. Given that the treatment group participants were not self-selected, the relatively short follow-up period, and the complexity of reproduction management, this is an encouraging result for the InCalf programme. However, only a minority of herds achieved the New Zealand industry target of a national average 6 week in-calf rate of 78%. The range of performance amongst herds was great suggesting that a high level of performance is achievable and hence there remain opportunities for improvement. Further studies to quantify the longer term benefits of this programme and to understand what the key drivers of the improvement due to treatment are needed.

4.2. Introduction

There is no agreed definition of agricultural extension (Black, 2000), but there are common themes within relevant literature. The Australasian Pacific Extension Network (APEN) suggests that extension involves the "…process of enabling change in individuals, communities and industries involved in the primary industry sector and with natural resource management". The goals of extension programmes are often broad, and keeping these programmes current is difficult (Hutjens and Baltz, 2000). One view is that the ultimate measure of success is the transfer and implementation of knowledge; using this definition, success can be difficult to assess (Hutjens *et al.*, 1980).

Extension programmes within the dairy industries have evolved to adjust to changes in the complexity and demography of dairy farming, both in New Zealand and internationally (Rivera, 1996). To date, most agricultural extension programmes have been based on principles of farmer participation, adult learning and action learning (Frost, 2000). However, the proportion of participants successfully adopting programme recommendations varies (Bell *et al.*, 2009). In addition, many farmers do not participate (Jansen *et al.*, 2010a), and some workers assume that these farmers are also 'unwilling' to adopt a change in management behaviour and, as a result, are 'poor performers'. This viewpoint has restricted the reach of the extension programme, as these farmers may require different value propositions and, frequently, extension providers are unwilling to risk failure with this group. This perspective also disregards the varied priorities of different farmers.

Extension programmes have commonly used research-driven, standardised models (Kristensen and Enevoldsen, 2008; Lam *et al.*, 2007; Peters *et al.*, 1994b) using a 'top-down' education philosophy and structured around recommendations from rural professionals about best farming practice. This method of farmer education has been compared with 'bottom-up' (farmer-centric), 'one on one' and 'formal structured' models; all models were found to have value in farmer extension (Black, 2000).

The InCalf extension programme for dairy farmers was developed in response to concerns by the Australian dairy industry regarding perceived deterioration of reproductive performance of the national herd. Using data collected between 1996 and 2000, the Australian National Dairy Fertility Project identified six key risk factors for poor reproductive performance in seasonal and year-round calving dairy herds, These were: (1) A protracted calving pattern; (2) young stock being reared to sub-optimal weights; (3) inadequate nutrition and associated inappropriate precalving body condition; (4) extent of negative energy balance in early lactation; (5) low sensitivity of oestrus detection; and (6) poor artificial insemination technique (Morton, 2003b, 2004). Bull management and animal health were subsequently added as further risk factors. The InCalf extension programme was developed using these findings, and aimed to provide a framework for key decision makers (KDMs) to make informed and critical decisions about these risk factors in their herd. The programme was based on a four tiered process (Britton *et al*., 2003) in which participants were encouraged to:

1. Assess the current reproductive performance of their herd
2. Identify and prioritise major management areas requiring change to improve their herd's reproductive performance
3. Prioritise management actions, develop plans for intended actions.
4. Implement these actions then review results of these actions, reflect on changes and plan for the following year.

The programme was delivered using a group–based approach (InCalf Farmer Action Groups).

The New Zealand dairy industry adopted the InCalf programme in 2007, with modifications made to targets using data from the New Zealand Monitoring Fertility Study (Xu and Burton, 2003) to incorporate the anticipated importance of anovulatory anoestrus in New Zealand dairy cows (Burke *et al.*, 2008). A national target of 78% 6 week in-calf rate by 2016 was adopted, based on the mean 6 week in-calf rate of the top quartile of study herds within the Monitoring Fertility Study (Anonymous, 2010). The InCalf extension program was launched to help achieve this target.

The majority of research on the efficacy of extension programmes in the dairy industry have focused on mastitis (Jansen *et al.*, 2010b; Penry *et al.*, 2011; Riekerink *et al.*, 2005) or lameness (Bell *et al.*, 2009) control programmes, with farmer participation generally resulting in decreases in incidence of mastitis, bulk milk tank somatic cell count and herd lameness scores. However, to our knowledge, there only two published randomised controlled evaluations of extension programmes in the dairy industry. One evaluated the effect of adopting a systematic preventative approach to lameness in heifers (Bell *et al.*, 2003), the other evaluated farmer compliance in the instigation of recommended management practices to reduce the herd-level bulk milk tank somatic cell counts (Green *et al.*, 2007). Worldwide, very few studies have formally evaluated extension programmes focused on the improvement of dairy herd reproduction (Burke and Verkerk, 2010; Varner *et al.*, 1989) and none have used a randomised controlled study approach, to our knowledge.

Development and implementation of a nationwide extension programme provided by trained rural providers is expensive. However, despite anecdotal case study evidence of positive effects of participation, no formal evaluation of the impact of KDM participation in the InCalf extension programme on herd-level reproductive performance had been undertaken in either Australia or New Zealand.

This study aimed to:

1. Quantify the effect of participation by KDMs in the InCalf Farmer Action Group extension programme on the 6 week in-calf rate of their herds, using a randomised controlled study design;
2. Assess possible interactions between participation of KDMs in the programme and biophysical and socio-demographic factors on the 6 week in-calf rate; and
3. Evaluate the effect of on-farm monitoring on 6 week in-calf rate using a second, passively-monitored control group.

4.3. Materials and methods

4.3.1. *Overview of the study*

This study was the third in a series collectively called the National Herd Fertility Study. It was undertaken in a sample of dairy herds from four regions of New Zealand; Waikato and Taranaki in the North Island, and North Canterbury and South Canterbury in the South Island (Figure 4.1). These regions were purposively chosen to represent a diverse cross-section of the dairy industry. A coordinating veterinary practice was located within each region. The study sample frame consisted of all dairy clients of these practices. Herds that fulfilled study eligibility criteria and agreed to participate were randomly allocated to one of three groups:

1. Participation in the InCalf extension programme (InCalf Farmer Action Group), with on-farm monitoring (treatment group; n = 73);
2. On-farm monitoring without participation in the extension program (actively monitored control group; n = 73);
3. Passive data collection only through the national dairy database (passively monitored control group; n = 22).

The passively monitored control group was included to evaluate the effect of on-farm monitoring, the so-called ‘Hawthorne effect’ (Holden, 2001). Reproductive performance of the treatment and actively monitored control group herds was measured using strategically timed pregnancy diagnoses during the two study years (2009/10 and 2010/11). Pregnancy diagnosis was timed to ensure that all potential conception dates within the first 42 days of the mating period could be accurately diagnosed. The proportion of cows pregnant in the first 42 days of the mating period (6 week in-calf rate) was used as the key measure of herd reproductive performance. Socio-demographic data were collected in questionnaires completed at the start (i.e. May/June 2009) of the study by trained interviewers.

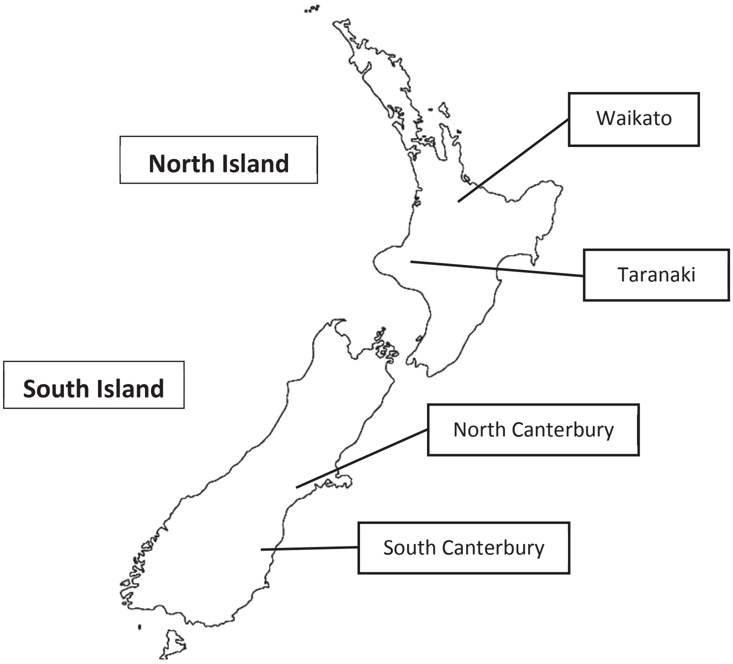


Figure 4.1. Map of the regions contributing herds to the New Zealand National Herd Fertility Study

4.3.2. *Sample size calculations*

A priori one tailed sample size calculations were performed using Win EpiScope 2.0 (Thrusfield *et al.*, 2001) based on detecting a 5% increase in 6 week in-calf rate between treatment and actively-monitored control groups. No account was taken of the clustering of herd-years within herd. Based on this, 124 herd-years were required in each of the groups over two years to have 80% power for detecting a significant difference at the 0.05 level if the true effect of treatment was a 5% difference in 6 week in-calf rate over both years.

4.3.3. *Herd selection*

Criteria for herd selection were described previously (Chapter 2). In summary, eligible herds must have been predominantly spring-calving (i.e. >90% of cows calved annually between 01 June and 30 November) and the herd's key decision maker (KDM) was likely to remain on the same site for the two years of the study. The KDM must have been considered by the regional coordinating veterinarian as being likely to comply with study protocol and data recording requirements. All eligible KDMs in each region were invited to an introductory meeting at the commencement of the study, when the study protocol and allocation to groups was described. Details of the content of the extension programme were not discussed however. Those that agreed to participate were allocated to groups.

4.3.4. *Allocation to groups*

To minimise bias due to differences in prior reproductive performance between groups, within each region, herds were ranked on the estimated 6 week in-calf rate in the lactation preceding the study (i.e. 01 June 2008 to 31 May 2009). The estimated 6 week in-calf rate for each herd was derived by the dairy herd testing service providers (LIC and CRVAmbreed), using an industry agreed algorithm (the InCalf Fertility Focus Report). In the absence of dated pregnancy diagnosis data for 80% of animals in a herd, the algorithm derives an estimate of the 6 week in-calf rate based on the timing of previous calving events, insemination data and proportion of inseminations that did not result in a subsequent repeat insemination in the following 24 days (non-return rate) where available.

Once ranked within each region, herds were randomly blocked into groups of two or three adjacently ranked herds. Herds were then randomly allocated, within block, to one of the three groups. Within each region, eighteen herds were allocated to participate in an InCalf Farmer Action Group (treatment group). The same number of herds was allocated to the actively monitored control group, and, where numbers allowed, further herds were allocated to the passively monitored control group. This occurred in three of the four regions, with the exception of north Canterbury, where only two additional herds were enrolled and so these were allocated to treatment and control groups (i.e. no passively monitored control group in North Canterbury), resulting in a total of 73 herds in each of treatment and the actively monitored control groups.

4.3.5. *Herd-year definition*

Once enrolled, permission to access data for the herd within the New Zealand Dairy Core Database (Livestock Improvement Corporation) was granted by each KDM for the duration of the study. The data included herd-, cow-, and lactation- level information. Management of data was described in Chapter 3. Mating start date (MSD) was defined for each herd in each of 2009/10 and 2010/11 as the first date where inseminations in cows were recorded that was followed by three or more days in the subsequent six days with inseminations as recorded in the national dairy database. The starts of each herd-year (i.e. 2008/09, 2009/10 or 2010/11) were then defined for each herd as the MSD minus 130 days.

4.3.6. *Lactation selection*

A 'herd-year' was defined as between the start of the herd-year (MSD – 130 days) and the beginning of the subsequent season, calculated as the subsequent MSD – 130 days or start of herd-year + 365 days if no subsequent MSD could be calculated. A 'cow-lactation' was included in analysis if it fulfilled the following criteria*:*

- The cow had calved between the start of the herd-year and 59 days after the MSD. This excluded yearling animals (animals mated for the first time at 12 to 15 months old) and animals without recorded parturitions in that herd-year.
- The cow was present in the herd at MSD, i.e. the cow had not been culled, sold or died between calving and MSD.

Cows removed after the MSD, but before pregnancy diagnosis, were included in the denominator for calculation of 6 week in-calf rate i.e. these cows were assumed to have not conceived by week 6 of the mating period. Cows with conception dates earlier than the MSD as identified by pregnancy diagnosis were excluded from analyses.

4.3.7. *6 week in-calf rate*

The key reproductive outcome was the 6 week in-calf rate, which was defined as the proportion of cows in each herd (meeting the lactation inclusion criteria) that were diagnosed as becoming pregnant during the first 6 weeks of the herd's breeding period. The protocol for pregnancy diagnoses was been described in detail elsewhere (Chapter 3). In summary, fetal age and conception date were determined by an experienced veterinarian using transrectal ultrasonography of the reproductive tract. In order to accurately determine conception dates for conceptions occurring in the first 6 weeks of the mating period, pregnancy diagnosis was mandated to be performed at 86 days (±7 days) after the MSD.

The effect of on-farm monitoring (i.e. mandatory pregnancy testing and annual questionnaires) was assessed by comparing the estimated 6 week in-calf rates between the actively– and passively-monitored control groups. Estimates were calculated as described in Chapter 3, and were used because pregnancy test data were not available for the passively-monitored herds.

4.3.8. *InCalf Farmer Action Group*

Treatment involved enrolment in a regional 'InCalf Farmer Action Group'. This 12 month group-based programme consisted of an introductory session then eight meetings: four structured and facilitated preparation ('prepare') session and four subsequent review sessions. Each prepare session was timed to precede the beginning of each of four management phases of the seasonal dairy calendar: calving, mating, mid to late lactation and the dry period. KDMs from treatment group herds participated in their first session in June 2009, the prepare session for calving. Within each prepare session, attendees were asked to formulate action plans for the following period using their own herd data (when available) and InCalf resource material. Two trainers facilitated whole group and small group discussions. Action plans were reviewed in the subsequent review session approximately 3 months later. This systematic review process captured KDM experience and plans for the following year based on discussion and review of the current study-year. The next prepare session was undertaken the following day. In general the prepare sessions took approximately 5 hours and the review sessions 2.5 hours. Where the KDM were unable or chose not to attend, follow-up was undertaken by the regional veterinarian. KDMs enrolled in the treatment group were charged $NZ 500 for the extension programme. The cost of the commercial programme was normally $NZ 2,000. The study subsidised the remainder of the cost to improve the probability of enrolment in the study.

4.3.9. *Univariate predictor variables*

Herd-level biophysical and socio-demographic data for the herds and KDMs in the treatment and active control groups were collected during interviews conducted at the start of the study, as previously described in Chapter 2. Herds were categorised into farm production systems on the basis of the proportion of cow nutritional requirements that were provided by imported supplementary feed (i.e. not grown on the home farm), ranging from 1 (no feed) to 5 (25–30% imported feed; Anonymous, 2009). This categorisation is commonly used by the New Zealand dairy industry, for example, when comparing herd performance. Due to small numbers of herds in some categories within regions, production systems were collapsed into two levels; low input or extensive (categories 1 to 3) and high input or intensive systems (categories 4 and 5).

Herd size was defined as the number of lactations in the herd meeting the inclusion criteria for that herd-year. Mean herd age was the average of cow ages at MSD for those cows whose lactations met the inclusion criteria for that herd-year. The predominant breed of each herd was determined as described previously in Chapter 2; where >75% of cows were either Friesian or Jersey breed, the herd was classified as predominantly Friesian or Jersey herd, respectively. All other herds were categorised as crossbred.

4.3.10. *Statistical analyses*

Data were collated in a purpose built SQL database then transferred to Stata 12 (StataCorp. 2011; *Stata Statistical Software: Release 12*; College Station; TX: StataCorp LP) for analyses. For each herd-year, continuous variables were described using means, standard deviations and range; categorical variables were described using proportions. The key outcome variable was the 6 week in-calf rate and the effect of participation in the InCalf Farmer Action Group was analysed at the herd-year level i.e. the unit of analysis was the herd-year. The effect of treatment on the 6 week in-calf rate was analysed as a proportion using a multivariable generalised linear model (GLM) fitted for a binomial distribution with Stata's -binreg- command, using the treatment and the actively-monitored control herds. Risk difference (difference in 6 week in-calf rates between groups) was also estimated, using the same model with an identity link. Study-year (i.e. 2009/10 or 2010/11) and region ('design factors') were forced into all models to account for any repeated measures effects of study-year and for any clustering by region. Provided sample size is adequate, adjustment for confounders is generally not required when analysing data from randomised controlled studies (Austin *et al.*, 2010). However, to asses if study groups were imbalanced with respect to important predictors of 6 week in-calf rate, ten further potential confounding variables (Tables 4.1 and 4.2) were then separately forced into the final model. These potential confounders were selected as they had previously been demonstrated to be associated with reproductive performance in Chapter 3 or were initially hypothesised to be biologically important. Potential confounders were fitted as categorical (Table 4.1) or continuous (Table 4.2) variables. Confounding was assessed based on the magnitude of change (≥20%) in the slope coefficient after fitting the potential confounder in the final model. Modification of the effect of treatment by selected variables was also assessed. First order interaction terms between treatment and each of region, study-year and biophysical and socio-demographic variables in Tables 4.1 and 4.2 were also tested; overall p-values for each interaction were obtained using joint Wald tests. Continuous variables were categorised into quartiles when assessing interactions. Robust standard errors were used for all models.

The effect of on-farm monitoring (i.e. mandatory pregnancy testing and annual questionnaires) was assessed by comparing estimated 6 week in-calf rates in 2009/10 and 2010/11 pooled between the actively– and passively-monitored control groups using a GLM as described above which included control group status (i.e. actively- or passively-monitored), region and study-year.

4.4. Results

4.4.1. *Study herds and lactations*

Numbers of herds and lactations allocated to groups, and numbers of lactations used for analyses, are summarised in Figure 4.2. Of the 168 herds that were enrolled, 14 were lost to follow-up, 9 in the treatment group and 5 in the actively-monitored control group. The KDMs of three herds in the treatment group withdrew their herds because they considered that the meeting format was not agreeable, two withdrew after poor meeting attendance, two withdrew due to time pressure and the remaining two provided no reason for withdrawal. Three of the actively-monitored control group herds withdrew after the KDM refused to comply with study protocol and KDMs of two herds volunteered time pressure as their reason for withdrawal. Ten herds were subsequently excluded from analysis due to incomplete data (principally lack of calving records preventing the Fertility Focus Report algorithm from estimating the 6 week in-calf rate) (n = 6), incorporation of a second herd under the same herd identification (n = 2) and change of KDM during the study (n = 2).

In the remaining 144 herds, 277,861 lactations were identified. Of these, 39,384 lactations (14%) were excluded; most of these (34,111 or 12%) were excluded due to having no recorded preceding calving date in that herd-year. Through validation with KDMs, these were, in the most part, cows that had not conceived the previous study-year but had been retained (‘carry-over’ cows) rather than unrecorded calving events. The remaining 5,273 (2%) lactations were excluded because the cows were removed between calving and MSD either due to death or involuntary culling.

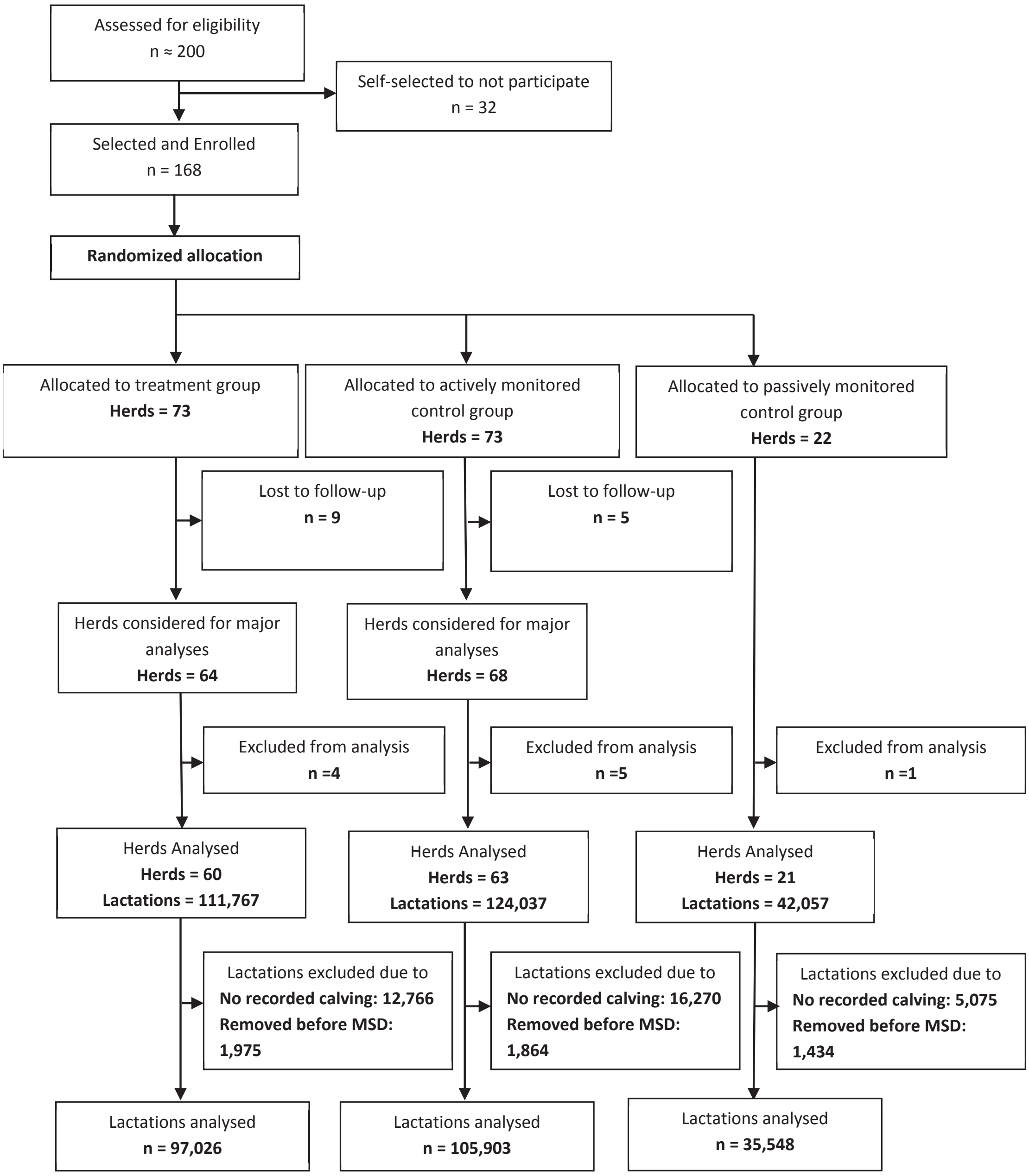


Figure 4.2 Numbers of herds allocated to treatment group, actively-monitored control group and passively-monitored control group and numbers of lactations used for analyses in the New Zealand National Herd Fertility Study

4.4.2. *Description of herds in the study*

The distributions of herds in the treatment group and actively-monitored control group for each of the categorical predictor variables are shown in Table 4.1. Distributions of herd size, mean age of herd and 6 week in-calf rate for 2008/09 for the treatment and actively-monitored control groups are summarised in Table 4.2. No difference were found between groups demonstrating that random allocation had resulted in balanced groups.

Table 4.1. Categorical predictor variables examined for their interaction with the effect of KDMs participating (Treatment; n=60 herds) or not participating (Control; n=63 herds) in an extension programme to improve reproductive performance in seasonal calving, pasture-based New Zealand dairy herds, with the number of herds in each category level and the proportions in each group.

Variable and level	Total n	Treatment group	Control group
Key Decision Maker			
Age category (years)			
20-29	12	10%	10%
30-39	32	25%	27%
40-49	51	38%	45%
≥50	28	27%	18%
Occupation			
Owner operator	71	63%	52%
Higher-order sharemilker[a]	23	17%	22%
Lower-order sharemilker	16	11%	15%
Farm manager	13	10%	11%
Post-school education			
No	44	33%	42%
Yes	79	66%	58%
Years of farming experience			
0-10	31	20%	30%
11-19	35	30%	26%
20-26	30	27%	22%
27-50	27	22%	22%
Herd			
Production system[b]			
Extensive	59	43%	53%
Intensive	64	57%	47%
Farm business model			
Family owned	101	81%	83%
Non-family owned	22	19%	17%
Predominant breed			
Friesian	13	11%	10%
Crossbreed	105	84%	87%
Jersey	5	5%	3%

[a] Higher-order sharemilkers were those that received >35% of farm, income whereas lower-order sharemilkers were those that received ≤35% of farm income

[b] Production systems were defined as: 1 = no imported feed used to feed herd, 2 = 4–14% imported feed fed to dry cows and cows grazed off-farm, 3 = 10–20% of feed fed to extend lactation and dry cows, 4 = 20–30% fed to extend both ends of lactation and dry cows, 5 = 25–30% imported feed used throughout the whole year (Anonymous, 2009)

Table 4.2. Mean (with SD) herd size, herd mean age of cows, and the 6 week in-calf rate in year preceding the start of the study of seasonal calving, pasture-based dairy herds where the key decision maker participated (Treatment; n = 60) or did not participate (Control; n = 63) in an extension programme to improve reproductive performance.

	Treatment group	Control group
	Mean ±SD	Mean ±SD
Herd size	540 ±317	571 ±303
Herd mean age of cows	4.82 ±0.36	4.81 ±0.36
6 week in-calf rate prior to the start of the study[a]	0.66 ±0.05	0.66 ±0.05

[a] Estimated using the InCalf Fertility Focus report algorithm

Mean herd size was 556 animals. The predominant breed was crossbred in 105/123 (85%) of herds. Most, 56 (42%), KDMs were in the 40-49 year old category, 77 (57%) were owner operators and 85 (64%) had post-school education. More KDMs were in the older two age groups (40-49 and ≥50 year age categories) in the North Island regions; 82% in the Waikato and 67% in Taranaki compared to 64% and 38% in north and south Canterbury regions, respectively. The mean years of farming experience was 18.8 years; this differed by region with Waikato KDMs having a mean of 23 years' experience (SD = 9), Taranaki 20 years' experience (SD = 10), north Canterbury 14 years' experience (SD = 10) and south Canterbury 17 years' experience (SD = 10).

4.4.3. *6 week in-calf rate*

Marginal mean 6 week in-calf rates estimated by GLM after accounting for region and study-year for the actively monitored control group was 66% (65% (95% CI 64 - 67%) in 2009/10 and 67% (95% CI 65 - 69%) in 2010/11), and for the treatment group was 68% (67% (95% CI 65 - 69%) and 69% (95% CI 67 - 70%) in 2009/10 and 2010/11; Table 4.3). There were large ranges in 6 week in-calf rates within both groups in both study-years (Figure 4.3). After accounting for region and study-year, 6 week in-calf rate in the treatment group was 1.95% (percentage points) (95% CI 0.01 - 3.89) higher than in the actively-monitored control group (*p* = 0.05).

Table 4.3. Marginal mean estimates of 6 week in-calf rate from a multivariable model to assess effects of participation (Treatment) or not (Control) of key decision makers in an extension programme to improve reproductive performance in seasonal calving, pasture-based New Zealand dairy herd from four regions, pooled over two study-years. Treatment group KDMs participated in the extension programme in 2009/10.

	Mean	95% CI	*P*-value
Group			0.05
Control group	66%	65 – 67%	
Treatment group	68%	67 – 69%	
Study-year			0.19
2009/10	66%	65 – 68%	
2010/11	68%	66 – 69%	
Region			0.06[a]
Waikato	67%	66 – 69%	
Taranaki	68%	66 – 71%	
North Canterbury	67%	65 – 69%	
South Canterbury	65%	63 – 67%	

[a] Overall significance of region

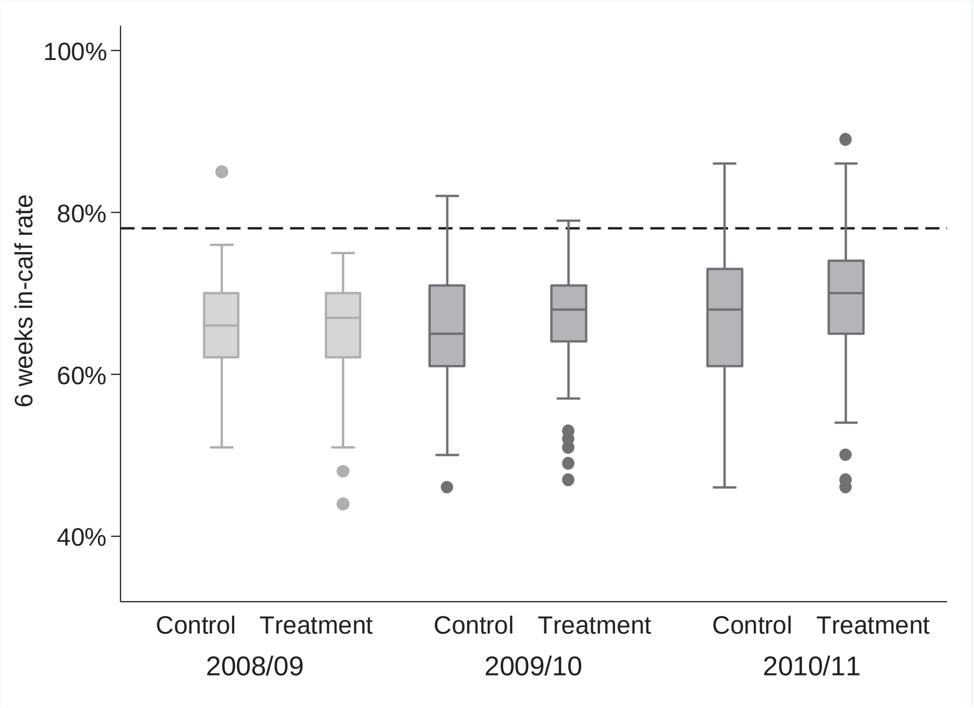


Figure 4.3. Box and whisker plot of 6 week in-calf rates of seasonal-calving, pasture-based dairy herds for 2009/10 and 2010/11, with the 2008/2009 (pre-enrolment) estimate of 6 week in-calf rate, where the key decision maker participated (Treatment) or did not participate (Control) in an extension programme in 2009/10 to improve reproductive performance. Boxes represent the 25th and 75th percentiles and whiskers represent the 5th and 95th percentiles; horizontal lines within boxes are medians; dashed line is the national target 6 week in-calf rate for 2020 of 78%.

4.4.4. *Interactions*

No significant ($p<0.05$) interactions were identified between participation in the extension programme and each of the ten biophysical and socio-demographic factors described in Tables 4.1 and 4.2. Observed marginal mean 6 week in-calf rates from the multivariable GLM were numerically higher in the treatment group than the actively-monitored control group within most region-year combinations (Figure 4.4). Differences between observed marginal mean 6 week in-calf rates for the treatment and actively-monitored control groups were similar in each study year. Herds in the lowest quartile of estimated 6 week in-calf rate prior to the start of the study had numerically the largest increase in 6 week in-calf rate over the two study years (Figure 4.5) but participation in the extension programme did not interact significantly with estimated 6 week in-calf rate prior to the start of the study ($p=0.33$). Similarly, herds where the KDM was in the lowest or highest quartile of dairy farming experience had numerically the largest increase in 6 week in-calf rate but no significant interaction was detected ($p=0.55$).

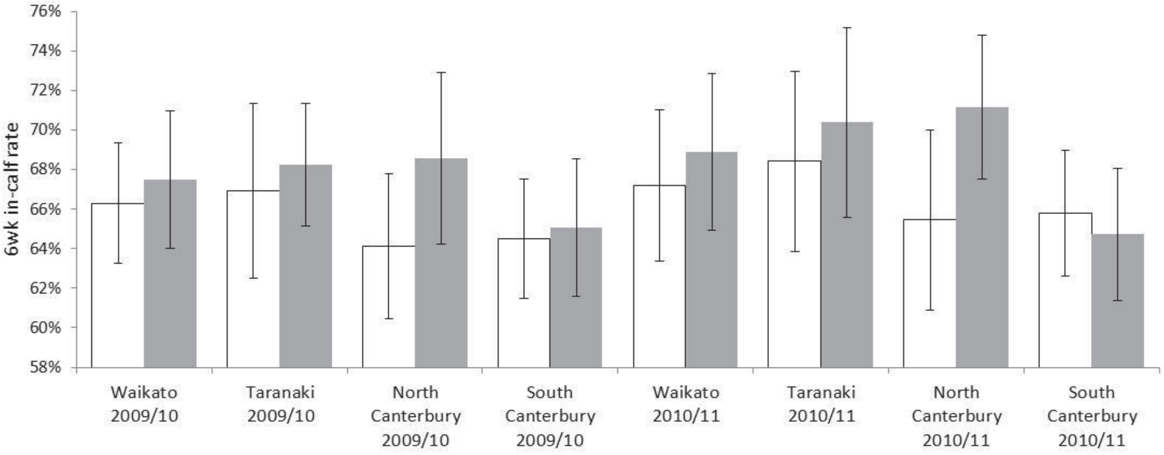


Figure 4.4. Marginal mean estimates (with 95% CIs) of 6 week in-calf rates of seasonal-calving, pasture-based dairy herds in four regions of New Zealand for 2009/10 and 2010/11, where the key decision maker participated (grey bars) or did not participate (white bars) in an extension programme in 2009/10 to improve reproductive performance.

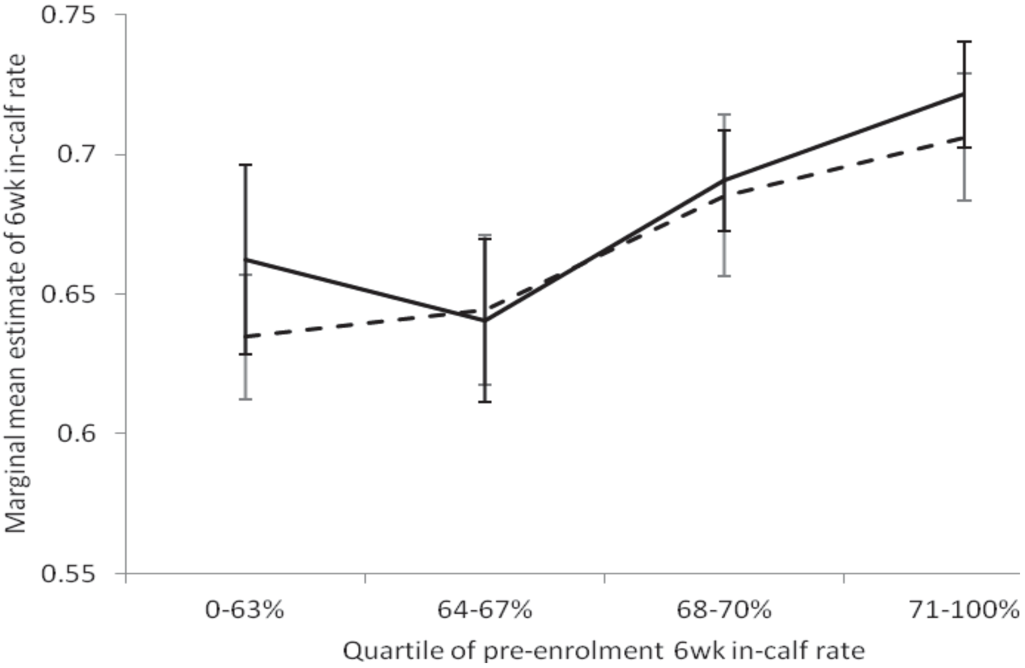


Figure 4.5. Marginal mean estimates (with 95% CI) of 6-week in-calf rates of seasonal-calving, pasture-based dairy herds where the key decision maker participated in an extension programme in 2009/10 to improve reproductive performance (solid line), or did not participate but whose herd was actively monitored (dashed line) by quartile of pre-enrolment (i.e. 2008/09) estimated 6-week in-calf rate.

4.4.5. *Potential confounding*

As there was numerical evidence that effects of treatment may have varied by both previous 6 week in-calf rate and quartile of KDM's years of dairy farming experience, these were not considered as statistically significant confounders. After fitting study-year and region, each of the remaining eight variables in Tables 4.1 and 4.2 were assessed for any confounding of the association between treatment and 6 week in-calf rate. After separately fitting each of these variables, risk difference estimates (*i.e.* the estimated effects of treatment) did not change by >12% (equating to an absolute change in estimated risk difference of 0.2 percentage points) and thus none were retained in the model to account for confounding

4.4.6. *Effect of on-farm monitoring*

There was no signficant difference in estimated 6 week in-calf rate between the actively-monitored and passively-monitored control groups (p = 0.56; Figure 4.6).

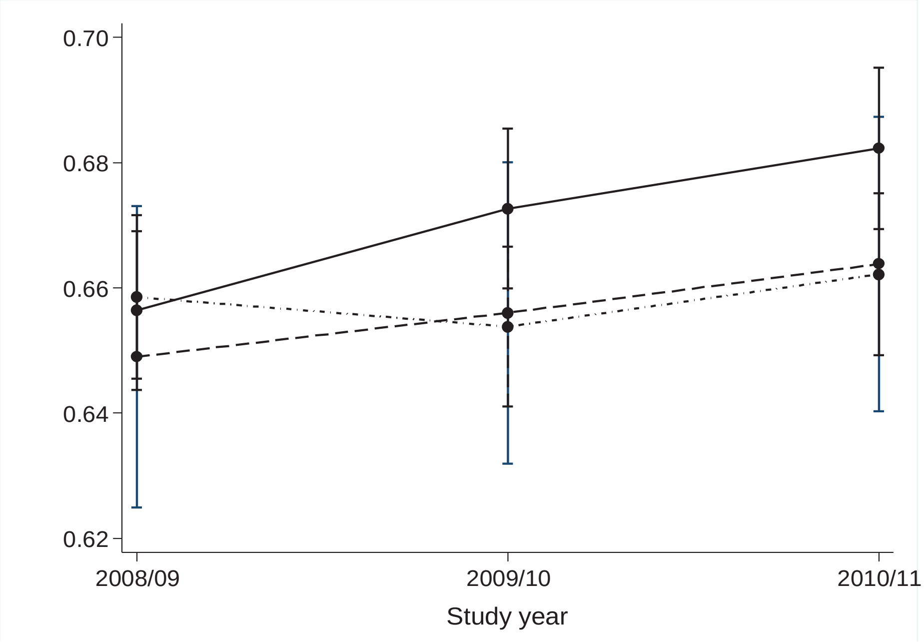


Figure 4.6. Marginal mean estimates (with 95% CI) of 6 week in-calf rates of seasonal-calving, pasture-based dairy herds for 2009/10 and 2010/11where the key decision maker participated in an extension programme in 2009/10 to improve reproductive performance (solid line), or did not participate but whose herd was actively (dotted line) or passively (dashed line) monitored, with the 2008/2009 (pre-enrolment) estimate.

4.5. Discussion

This study demonstrated that involvement by KDMs in a reproductive management extension programme (InCalf Farmer Action Group) results in improvement in their herd's 6 week in-calf rate. The estimated average improvement was 2% (2 percentage points) over both the year of participation and the following year.

Our effect estimate of 2% is a population averaged effect, and the effects of participation varied widely between herds. The objective of the extension programme was to effect change in reproductive performance through the adoption of improved on-farm management. The Farmer Action Groups was designed to provide practical advice and support in adopting these behaviours and how best to action these with the result that action plans were formulated and written down. The proposed management changes and methods for their implementation were farm specific and not constrained by the extension programme. As expected, there were differences amongst KDMs in the priority areas they selected for change and in the degree of enthusiasm and commitment with which they implemented their plans.

The use of RCTs to evaluate the efficacy of agricultural extension programmes is rare, with two prior examples that we are aware of (Bell *et al.*, 2003; Green *et al.*, 2007). Effects of programs have been assessed using before/after comparisons (Jansen *et al.*, 2010b) and surveys assessing management practices after programs have been delivered for some years (Riekerink *et al.*, 2005). But in the absence of a control group, the effect of an extension program cannot be confidently inferred. The National Herd Fertility Study is novel in that it assessed the effect of a reproductive extension programme compared with a representative control group.

Interactions between treatment and each of biophysical and socio-demographic factors on the 6 week in-calf rate were explored to test the universality of treatment. If interactions had been detected, the implication is that extension packages may have to be adapted, for example to specific KDM demographics, regions or farm systems, increasing the cost and complexity of such programs. No significant interactions were found, so this study provides no evidence that such interactions exist. While the study had limited statistical power to detect such differences, if very large interactions existed, they would have likely been detected.

Treatment by region interaction was tested as the provision of the InCalf Farmer Action Group and follow-up actions may have varied by region. We found no evidence of such interaction. This may have been because the content and process of the Farmer Action Group meetings were prescribed and one of two trained facilitators was from outside the region to ensure consistency between the regional meetings. However, although the actual Farmer Action Group meetings were likely consistent across regions, there may have been differences in the degree of follow up of KDMs (and staff) by the regional coordinating veterinarians and colleagues depending on their degree of adoption and acceptance of InCalf. Modelling has demonstrated that a veterinarian's prior belief about a program's efficacy affects the uptake, and hence financial return, by herd owners (Green *et al.*, 2008). Although the overall interaction was not significant, differences in observed 6 week in-calf rates between the treatment and actively-monitored control groups varied by region (Figure 4.4.), and this warrants further investigation. These differences were most marked between the two South Island regions, even though in both regions, the programme had been well integrated into reproductive programs of the regional veterinary practices.

Interaction between participation in the programme and study-year was evaluated as any effects of the InCalf Farmer Action Group may have differed between study-years. As exposure to the facilitated meetings occurred only in the first study-year, some practices may have been implemented with greater rigour in that year than the following year, while other practices identified in the prepare sessions could not have been implemented in the first year to affect 6 week in-calf rate in that year. There was no significant interaction, suggesting the effect of participation did not change between study-years. However, this short study was insufficient to assess the longer term effects of participation; some management practices that could have been adapted would take several years to effect reproductive performance. If, for example, a KDM prioritised improved calf growth rates in the first study-year (2009/10), then the effect of any improvement in live weight of heifers born in 2009/10 on reproductive performance would not have occurred in the milking herd until the 2011/12 study-year. Alterations to calving pattern may also take some years to have full effect, due to the difficulty in altering calving pattern quickly and the iterative effects of calving pattern (i.e. calving pattern markedly affects 6 week in-calf rate, which in turn can affect calving pattern in the following year). On the other hand, implementation of learning may wane over time. In a demonstration project of dairy extension in the United States involving 24 herds over two years, the results were largely positive during the two year trial but declining performance was observed two years after the extension programme had finished (Cassel *et al.*, 1994; Peters *et al.*, 1994a; Peters *et al.*, 1994b). That project however, did not use a control group. Further work is required to define the long term biological and economic effect of participation in the InCalf programme. Were the biological effects of being involved in InCalf to continue, or even accumulate, for some years beyond the end of the Farmer Action Group, then the economic return of involvement in the program would likely be substantially higher than if the effects only lasted for 2 years.

In the US demonstration project, the largest benefit was seen in herds ranked lowest in terms of performance and thus where the greatest room for improvement was identified (Cassel *et al.,* 1994). No significant interaction between treatment group and pre-enrolment 6 week in-calf rate was detected in the current study, but a numerically larger improvement of the previously poorer performing herds was observed in the treatment group compared to the actively-monitored control groups reflecting the findings from the US project. The results of this current study provide some evidence that KDMs managing lower performing herds may be better targets for extension. This may be because these herds are potentially most likely to be inhibited by one or more substantial risk factors and therefore likely to have a bigger response to participation if these risk factors are modified. At national level, the largest change in performance may be achieved by focusing on those herds with the poorest current performance. If so, this challenges the dogma that KDMs managing lower performing herds are slow adopters and less likely to gain from extension programmes.

The randomised controlled study design allows robust inference of results between groups, being less prone to bias than observational studies and much less prone than before/after comparisons. However, a number of potential biases in this study could have occurred: Firstly, the method of randomisation required that estimates of 6 week in-calf rate were derived from herd records in order to rank herds before allocation. Due to between herd variation in the accuracy and completeness of records in the lactation preceding enrolment, it is likely that there would have been variation in the proportion of cow records not included in the estimates of 6 week in-calf rate used to rank herds for allocation to groups. However, there is no reason to believe that errors in estimates of 6 week in-calf rate used to rank herds were systematic (i.e. differed in some systematic way between groups). If so, such errors would have caused minimal confounding and so had little effect on our results.

The external validity of this study is probably high as herds were drawn from widely disparate geographical regions across New Zealand, representing a wide range of production systems and herd sizes. The enrolled herds were probably broadly representative of the dairy industry in these regions (Chapter 2). The sample frame for the study was the dairy client base list of the coordinating regional veterinary practice. Although there may have been some inherent selection bias from using the client base sample frame rather than a selection from all herds in the region, it was considered minimal. In two of the regions, the collaborating veterinary practice serviced all or the great majority of herds, hence the sample frame drawn from the practice was essentially that of the region. In the other two regions, a number of other practices service herds in the area, but the study practices were still dominant, hence again the sample frame represented the majority of available herd present in the region. The coordinating veterinarians were also asked to assess the likelihood that herds willing to enrol would keep good records and follow the protocol. This was a subjective evaluation and could have led to selection of herds not representative of all herds in the region. However, only a small number of herds were not enrolled on this basis (n = 4). Herds were also selected on the basis that the KDM of the herd was planning to remain for the duration of the study. This was done as it was assumed that as the KDM was the focus of the extension program and hence if the KDM moved during the study that the treatment effect may be reduced or lost. As in commercial reality, if KDM‘s do enrol in InCalf Farmer Action Groups and then do move, then the effect of treatment may be underestimated. However at national level, so long as the KDMs that move locations stay in the dairy industry, the effect of being involved in the InCalf Farmer Action Group may then occur on the next farm the KDM is involved with, so some effect of treatment may still occur.

It seems likely that effects of treatment would be greater in herds where the KDMs were specifically focussed on improving herd reproductive performance using this group learning process. Our study population was not limited to KDMs prioritising improvements in herd reproductive performance, and not all KDMs enjoy or participated actively in Farmer Action Groups. The InCalf Farmer Action Group was an interactive, facilitated group forum that, in normal commercial conditions, would likely be attended by a subset of KDMs who would have either volunteered or been selected by a regional coordinator as being likely to be responsive to that learning environment. We speculate that 6 week in-calf rates would increase more in herds managed by these KDMs than we observed.

There was a risk that information was disseminated from the KDMs or veterinarians participating in the InCalf Farmer Action Group to KDMs of the actively- and passively-monitored control groups. If such information was disseminated and the control group KDMs implemented changes as a result of this information, the effect of treatment would have been underestimated. This risk was discussed with the regional veterinary practices and practice-wide promotion of the InCalf programme (e.g. via newsletter articles) was restricted during the 2 years of the study. Further, the benefit of the Farmer Action Group was hypothesised to be in the facilitated and interactive learning increasing understanding and subsequent timing of established behaviour, rather than provisional of technical information *per se*. Thus the effect of information being disseminated to the control groups was considered to be unlikely to result in substantial farm changes in these groups. However, the degree to which information was disseminated beyond the treatment group and its effect on the control group is unknown.

No significant difference was found in estimated 6 week in-calf rates between the actively- and passively-monitored control groups, and observed mean 6 week in-calf rates were similar in both of these groups in the two study years (2009/10 and 2010/11). Thus the presence of technicians on farm collecting heifer weight, body condition score, disease and pregnancy test data, and conducting interviews does not appear to have resulted in a marked improvement in reproductive performance. This provides confidence that the observed effect of being involved in InCalf was not markedly underestimated due to occurrence of the Hawthorne effect amongst the actively-monitored control herds.

We conclude that enrolment in the InCalf Farmer Action Group extension program improves the 6 week in-calf rate, and that the treatment effect is not modified substantially by region, study-year or any of the biophysical and socio-demographic variables assessed. Thus, treatment effects are broadly consistent over a range of farm systems, geographic regions and KDM types. Given that the treatment group participants were not self-selected, the relatively short follow-up period, and the complexity of reproduction management, this is an encouraging result for the InCalf programme. However, only a minority of herds achieved the New Zealand industry target of 78% 6 week in-calf rate by 2016. The range of performance amongst herds was wide suggesting that a high level of performance is achievable and hence there remain opportunities for improvement. Further studies to quantify the longer term benefits of this programme and to understand what the key drivers of the improvement due to treatment are needed.

CHAPTER 5

Effects of participation by farmers in InCalf Farmer Action Groups on key management factors affecting reproductive performance in dairy herds

Tom S. Brownlie, John M. Morton, Cord Heuer and Scott McDougall

5.1. Abstract

An InCalf Farmer Action Group is a group-based reproductive management extension programme designed to help managers of dairy herds improve herd reproductive performance. The objectives of the work reported in this study were to assess effects of participation by key decision makers (KDM) in the InCalf Farmer Action Group on six key management factors that affect reproductive performance; describe KDM intentions to change management behaviour(s) affecting each management factor after participation in the InCalf programme, describe their self-reported degree of success in making these changes, and to assess the association between these intentions and herd performance for the key management factors. Seasonal-calving dairy herds from four regions of New Zealand were enrolled in the study. Of those enrolled, results were analysed for 63 herds where the KDM participated in a group-based 12-month extension programme (treatment group) and outcomes were compared with 60 control herds. Intentions to modify management behaviour were recorded using the formal written action plans made during the extension programme. Key management factors assessed were calving pattern of the herd, precalving heifer live weight, precalving and premating body condition score, oestrus detection, anoestrus cow and bull management. Participation in the InCalf programme was associated with an improvement in heifer live weight, premating body condition score and oestrus detection but no effects were observed on calving pattern, anoestrus cow management, or bull management. Intention to change was associated with improvement in heifer live weight, but not with any other outcomes. Herds with greater numbers of proposed actions had lower 6 week in-calf rates in the second study year than herds that proposed fewer actions. The InCalf Farmer Action Group can improve the performance of three known key management factors that affect reproductive performance.

Further work is needed to understand where improvements can be made to InCalf to ensure change in the remaining management factors. Within the InCalf Farmer Action Group the majority of farmers expressed dissatisfaction with specific management practices. However the process of writing down intentions to change these practices was not associated with this improvement. A more effective strategy to ensure Specific, Measureable, Attainable, Relevant, Timely (S.M.A.R.T.) objectives are proposed should be investigated to improve the programme further.

KEYWORDS Dairy, New Zealand, reproduction, InCalf, extension, management

5.2. Introduction

The reproductive performance of dairy herds is determined by a large number of risk factors. A series of key risk factors in seasonal-calving, pasture-based systems were identified in the Australian National Dairy Herd Fertility Project (Morton, 2003b, 2004). Within that project, a large number of putative risk factors were assessed and a smaller number of key factors were used in the development of the InCalf reproduction extension programme for dairy farmers. The following key management factors were subsequently identified as major determinants of herd reproductive performance (Britton *et al*., 2003).

1. Calving pattern (distribution of intervals from each cow's calving to herd mating start date (MSD)
2. Precalving heifer live weights
3. Precalving body condition scores
4. Oestrus detection
5. Artificial insemination techniques
6. Bull management

These factors, alongside anoestrus cow management and animal health, have been confirmed as risk factors for reproductive performance by work both in New Zealand and internationally (Hanzen *et al.*, 1996; Macmillan, 2002a, b, McDougall, 2006). As such, these risk factors were incorporated as key components of the InCalf reproductive management extension programme when it was adopted by the New Zealand dairy industry in 2008. The principle aim of the InCalf programme was to achieve a measurable improvement in reproductive performance of New Zealand dairy herds, as in Australia (Britton *et al.,*, 2003, Burke *et al.*, 2008). The InCalf programme used 'Farmer Action Groups' to encourage farmers to apply a structured approach to the measurement and accurate interpretation of the overall reproductive performance of their herd, to identify constraints among the key management factors, and to plan actions to reduce the constraints. Continued improvement in herd performance was promoted through periodic review and evaluation of the success of current strategies. Each farmer could participate in four Farmer Action Group prepare meetings and subsequent review meetings, all held over a 12-month period.

At each of the four Farmer Action Group prepare meetings, participants systematically addressed two to three key management factors in advance of critical times in the dairy year. For each factor, current performance was assessed. Where a farmer indicated dissatisfaction with one or more management behaviour(s) associated with a particular key management factor, intentions to change behaviour(s) could be proposed by that farmer. Theorists in behavioural science agree that intention to change is the key determinant of behavioural change (Ajzen, 1991a, Coudel *et al.*, 2011). From a meta-analysis of 47 randomised controlled experimental studies in public health, medium to large intention to change was needed to result in change in behaviour (Webb and Sheeran, 2006). To the authors' knowledge, studies evaluating the relationship between intention to change behaviour by dairy farmers, actual behavioural change ('actions') and effects on management factors have not been previously undertaken.

The National Herd Fertility Study was a multi-centre, multi-year randomised controlled study undertaken in New Zealand dairy herds between 2008 and 2011 to quantify the effect of KDM involvement in InCalf Farmer Action Groups (Chapter 2). As outlined in Chapter 4, farmer participation in the InCalf Farmer Action Group resulted in a 2% increase in average herd 6 week in-calf rate during the subsequent year, presumably due to improvement in one or more of the above key management factors. Six of these factors are explored in the current study.

The objectives of the work reported in this study were to:

1. *Assess effects of KDM participation in the InCalf Farmer Action Group on six key management factors that affect reproductive performance;*
2. *Determine the proportions of KDM that intended to change management behaviour(s) affecting each key management factor after participation in the InCalf Farmer Action Group, and their self-reported degree of success in making these changes;*
3. *Assess associations between intention to change and herd performance for the key management factors.*

5.3. Methods

5.3.1. *Overview of the study*

The work reported in this paper is the fourth of a series of studies collectively named the *National Herd Fertility Study*. The primary aim of the study was to quantify the effect of an InCalf reproductive management extension programme, delivered through Farmer Action Groups, on the reproductive performance of a representative sample of dairy herds from four New Zealand regions: Waikato and Taranaki in the North Island, and north and south Canterbury in the South Island. These regions were purposively chosen to represent a diverse cross-section of the dairy industry. Herds were selected from eligible dairy clients of the coordinating veterinary practices located within each region. Within each region, herds that fulfilled eligibility criteria (Chapter 2) were enrolled and ranked on their estimated pre-enrolment 6 week in-calf rate and blocks created of either two or three herds with adjoining ranks. Within these blocks, herds were then randomly allocated to one of three groups (Chapter 4):

- Participation in a Farmer Action Group with on-farm monitoring and data collection through the national dairy database, (treatment group; n = 73);
- On-farm monitoring and data collection through the national dairy database (actively monitored control group; n = 73);
- Passive data collection only through the national dairy database (passively monitored control group; n=22) and not analysed in the work reported in this study.

Farmers allocated to the treatment group participated in InCalf Farmer Action Group activities from June 2009 to May 2010, with data collection continuing until May 2011.

The outcomes of herds and lactations through the study-years have been summarised (Chapter 4). Following losses to follow-up and exclusions, 63 of 73 herds allocated to the treatment group and 60 of 73 herds allocated to the control group were analysed in the work reported in this study. KDM from fourteen herds allocated to the treatment and actively monitored control groups withdrew from the study and nine herds were excluded due to incomplete data (Figure 4.2).

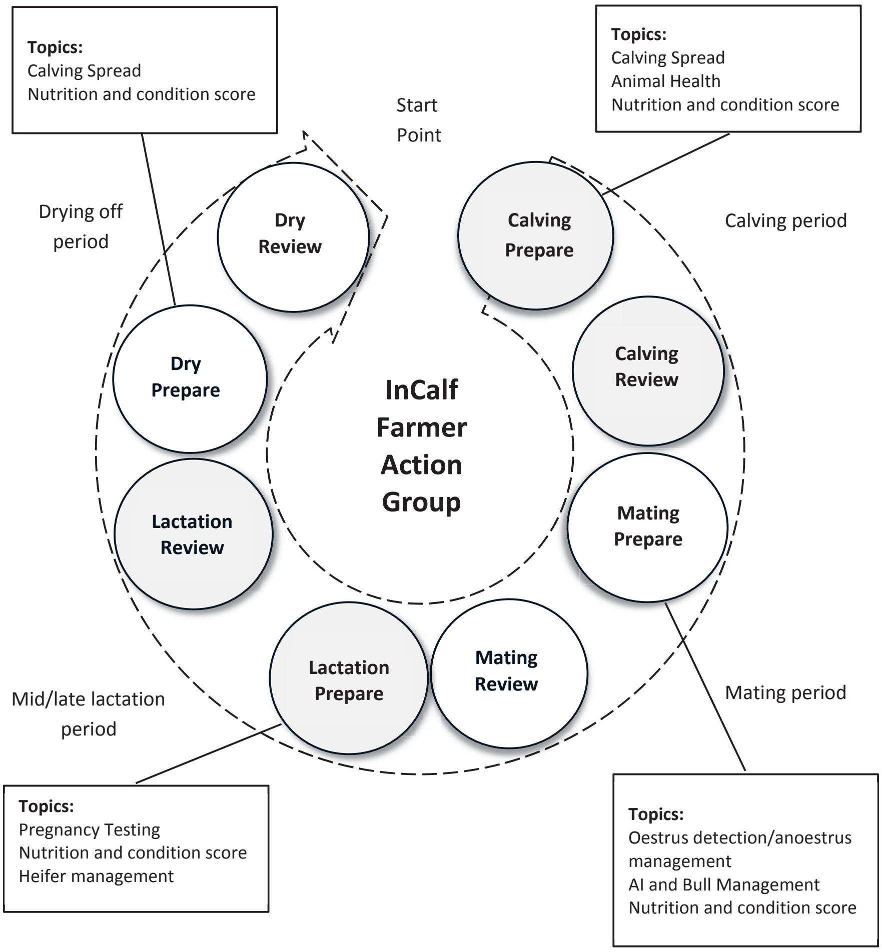


Figure 5.1. Schematic view of the InCalf Farmer Action Group process undertaken regionally by farmers allocated to treatment in the New Zealand National Herd Fertility Study. Four meetings were held over a 12-month period. Each circle represents either a prepare or subsequent review meeting for each of four periods in the seasonal-calving dairy year

5.3.2. *InCalf Farmer Action Group*

The seasonal calving dairy year was divided into four periods corresponding to calving, mating, mid/late lactation and the dry period (Figure 5.1). Over a 12-month period, one prepare meeting was held in each period, and management factors associated with the period discussed. Two or three pertinent management factors were described to participants at the beginning of each meeting. A corresponding review meeting was held at the end of that period before the next periods prepare meeting. All meetings were facilitated by trained advisers and in all regions, the first prepare meeting was the calving session, and was conducted in June or July 2009. Farmer attendance at each meeting was recorded.

Within each prepare meeting, farmers could utilise InCalf resource material, including their herd's InCalf Fertility Focus Report (a standard analysis of their herd's overall reproductive performance and performance for some key management factors in the previous year i.e. 2008/09) and the InCalf book for Dairy Farmers (Burke *et al.*, 2007), to evaluate their herd's overall reproductive performance and performance relating to key management factors compared with national targets. Farmers were then asked to quantify their satisfaction with predetermined aspects of key management factor in two to six questions (e.g. 'were you [the farmer] 'very satisfied', 'could be better' or 'not satisfied/unsure' that everyone on the farm understands the need to achieve a high proportion of early calving cows'). Farmers less than 'very satisfied' were encouraged to use InCalf resource material within small peer groups to formulate written actions plans to improve the overall reproductive performance of their herd through management changes focussed on key management factors. Farmers were encouraged to propose actions with S.M.A.R.T. objectives (Doran, 1981).

Action plans and review session responses were duplicated using carbonless copy paper included in the resource material. The duplicated sheets were collected by facilitators with the objective of undertaking follow-up with farmer after the meetings. Actions and review responses were documented using these duplicated sheets.

5.3.3. *Overview of key management factor assessment*

Measures of key management factors are summarised in Table 5.1, and are described in detail below. The effect of participation in the InCalf Famer Action Group was assessed for each management factor by comparing these measures between treatment and control herds. Where the management factor was first measured in 2009/10 after treatment group farmers had addressed the relevant topic in the InCalf Farmer Action Group, measures for both study years (i.e. 2009/10 and 2010/11) were pooled for analysis as dependant variables. For other factors where the first measure preceded the relevant prepare meeting, only measures for the 2010/11 study year were used as the dependant variable as the major relevant prepare session had not been held in time for farmer to substantially influence them in the 2009/10 season.

Table 5.1. Summary of primary measurements used to assess change in management factors associated with reproductive performance in seasonal calving pasture-based New Zealand dairy herds after farmer participation in the InCalf program.

Key management factor	Key measurements	Study-years analysed[a]		Data for measure derived from
		Objective 1[b]	Objective 3[cd]	
Calving pattern	Proportion of calvings in year that occurred on or before day 42 after the PSC ('early calvings')	2	2	National Dairy database
Heifer management	Mean of differences between mean precalving live weight and target weight ('mean-weight-gap')	2	2	Heifer live-weights and lwtBVs[e]
Nutrition and body condition score (BCS)	Mean precalving BCS	2	2	BCS
	Percentage of herd not meeting target precalving BCS of ≥5/10 and <6/10	2	2	BCS
	Mean premating BCS	1 & 2[g]	2	BCS
	Percentage of herd not meeting premating BCS of ≥4.5/10	1 & 2[g]	2	BCS
	Difference in mean BCS for herd between calving and premating	2	2	BCS
Oestrus detection	Proportion of 3 to 8 year old cows that calved <42 days after PSC, that were inseminated at least once in the first 21 days after the MSD	1 & 2[g]	2	National Dairy database
Anoestrus cow management	Anoestrus treatment date relative to MSD[h]	1 & 2[g]	2	National Dairy database
Bull management	Ratio of mean of hazards of conception in each of the last three weeks of the artificial insemination period to that in the first three weeks of the bull mating period (i.e. the next 3 weeks)	1 & 2[g]	2	Pregnancy diagnosis

[a] Study-year 1: 2009/10 (year of exposure to treatment (InCalf Farmer Action Group), study-year 2: 2010/11

[b] Objective 1: Assess effects of KDM participation in the InCalf Farmer Action Group on six key management factors that affect reproductive performance

[c] Objective 3: Assess associations between intention to change proposed during the InCalf Farmer Action Group and herd performance for the key management factors, Objective 2 did not require risk factor measures.

[d] Study year 1 (2009/10) primary measure included as covariate to account for potential confounding due to correlation between knowledge of prior performance and intention to modify management behaviour

[e] LwtBVs: genetic breeding values for live-weight

[g] Study-years pooled for analysis

[h] Categorised as early (ie before MSD) or late (on or after MSD)

Associations between intention to change management behaviour(s) documented in 2009/10 during the InCalf Famer Action Group and 2010/11 herd outcomes for the corresponding key management factor were assessed within treatment group herds.

Artificial insemination and animal health topics were not analysed in this study. In 93% of study herds, commercial artificial insemination technician services were used and consequently farmers were unable to undertake substantial changes in artificial insemination management. Animal health data were not recorded consistently between study herds.

Some topics were discussed at more than one prepare session (Figure 5.1), for example, nutrition and body condition. For these management factors proposed actions from each prepare session and responses to repeated questions in subsequent review sessions were aggregated for analyses.

5.3.4. *Calving pattern*

Calving pattern was assessed as the cumulative proportions of calvings (including heifers, purchased cows and cows induced to calve prematurely) that occurred in the first 42 days (six weeks) after the herd's planned start of calving (PSC) date (calved <42 days after PSC) in the 2010/11 study-year (Table 5.1).

Four determinants of calving pattern were also measured, to assess effects of treatment on specific practices that alter calving pattern. These determinants were: 1) of the cows that were diagnosed as conceiving late in 2009/10 (≥42 days after MSD), the proportion that were culled before the 2010/2011 calving period. 2) of the cows that were diagnosed as conceiving late in 2009/10, the proportion that were induced to calve early in the 2010/2011 calving period, 3) of the cows that were purchased soon before the 2010/11 calving period, the proportion of calvings that occurred early in the 2010/2011 calving period, and 4) the proportion of calvings of heifers that occurred early in the 2010/2011 calving period. To calculate these measures, pregnant cows that were culled before the 2010/11 calving period or artificially induced to calve during that calving period were each categorised as either early or late conceiving (< or ≥42 days after MSD, respectively) based on diagnoses made by transrectal ultrasonography in 2009/10. Purchased animals and heifers (both being cattle where conception dates in 09/10 were not available), were each categorised as early or late calving (<or ≥42 days after the herd's PSC date (MSD + 282days) respectively) calving using calving dates. If purchased animals were induced to calve, they contributed to the proportion induced. Where a cow or heifer had an abortion recorded in 2009/10, it was excluded from these analyses. Where yearling heifer matings were commenced in advance of the lactating herd, heifer calving dates were still categorised as early or late based on the herd PSC as this was considered a purposive action to improve calving pattern (through reducing the percentage of calvings that were late) and, therefore, was not penalised.

Calving pattern was addressed in two of the prepare sessions (i.e. calving and dry period) (Figure 5.1) and proposed actions categorised (Table 5.3). Proportions of cows that calved <42 days after PSC in the herd in 2010/11 were compared between treatment and control groups. Associations between having intention to change management behaviour(s) affecting calving pattern and calving pattern in 2010/11 were also analysed.

5.3.5. *Precalving heifer live weight*

Heifer rearing was evaluated in each herd in each year using the mean difference between measured live weight before calving and mean target weight (mean-weight-gap). For each herd in both study years, 70 heifers (between 22 and 24 months of age) were randomly selected using systematic sampling and weighed using an electronic weighing system (TruTest) 14 (range ±7) days before the PSC. In herds with less than 70 heifers, all heifers were weighed. Estimated target live weight values were derived using a heifer growth model (Bryant *et al.*, 2004) that calculates target adult live weights for each heifer adjusted for the heifer's genetic breeding value for live weight, where a genetic breeding value of 0 equates to the national mean adult precalving live weight of 503 kg. For example, a heifer with a live weight (genetic) breeding value of -22 would have an estimated adult live weight of 481 kg. Individual precalving 'target' weights for each heifer were calculated as 90% of the estimated precalving adult live weight at 22 months (Penno, 1997). Heifers were weighed at between 22 and 24 months however, there was little variation in heifer weight between 22 and 24 months (McNaughton *pers comm*.). For each heifer weighed, the difference between the measured heifer live weight and target live weight (measured heifer live weight minus target live weight; the 'weight-gap') was calculated. Thus, heifers that were below target had negative gaps. The averages of the weight-gaps within each herd in each year were calculated and termed the 'mean weight-gap'.

Mean-weight-gaps in 2010/11 were compared between treatment and control groups. Heifer management was addressed in the Farmer Action Group mid/late lactation prepare meeting (Figure 5.1). The association between intentions to modify heifer management on mean-weight-gap in the 2010/11 study-year was also assessed.

5.3.6. *Body condition score (BCS) and nutrition*

In each study-year, the mean precalving and premating BCS for the herd, and the difference between means, were calculated. The proportions of cows not achieving precalving targets of BCS ≥5 and ≤5.5, and the premating target of BCS ≥4.5 were also calculated from each herd in each year.

A minimum of 70 adult cows (>2 years) were selected in each herd and body condition scored by a trained technician using a ten point scale (Roche *et al.*, 2004) >14 days before the herd's PSC (precalving BSC). A second systematic random sample of approximately 70 cows were scored approximately 14 days before the herd's planned MSD (premating BSC) in both study-years. Where possible, body condition scoring was undertaken in the dairy shed or equivalent handling facilities to allow systematic random sampling and 'hands-on' (i.e. tactile as well as visual assessment. Otherwise, technicians used a visual scoring assessment of cattle at pasture, walking diagonal lines through paddocks to score a representative sample of cows. To ensure within-herd consistency, the same technique was used in all subsequent visits to that herd.

BCS was addressed in all four of the InCalf Farmer Action Group prepare meetings (Figure 5.1). Target scores (Roche *et al.*, 2007) had been previously incorporated into the InCalf resource material. Questions of satisfaction regarding nutrition varied between sessions depending on the stage of the lactation cycle. Proposed actions were categorised as intention to undertake staff training, condition scoring of cattle, quick nutritional checks (at least one of seven daily measures recommended in InCalf resource material), preparation to react to changing nutritional demands, or introduce or modify a transitional diet in the precalving period.

Mean precalving BCS, the difference between means from precalving to pre-mating, and proportions of cows not achieving the precalving BCS target, all in 2010/11, were compared between treatment and control groups. The association between intention to modify BCS and nutrition management and these measures in the 2010/11 study-year was also assessed. Mean pre-mating BCS and proportions of cows not achieving the pre-mating BCS target in both 2009/10 and 2010/11 were pooled for analysis.

5.3.7. *Oestrus detection*

The outcome measure was the proportion of mature (3 to 8 year old) cows that calved <42 days after PSC, that had at least one insemination recorded in the first 21 days of the mating period ('early-calved mature cow 3 week submission rate') in each herd pooled for both study-years. These cows were considered least likely to have been anoestrus in the first 21 days of the mating period. So, assuming cycling cows ovulated every 21 days, those not inseminated were likely to have ovulated but not been detected by herd staff. The assumption was made that cows that received a false positive (i.e. non-oestrus) insemination in the first 21 days also had an non-recorded ovulation in the same period.

Oestrus detection was addressed as one of two components of the submission rate topic within the InCalf Farmer Action Group mating prepare session (Figure 5.1). Early-calved mature cow 3 week submission rates in both 2009/10 and 2010/11 were compared between treatment and control groups. The association between intention to modify oestrus detection and this measure in both 2009/10 and 2010/11 was also assessed.

5.3.8. *Anoestrus cow management*

The outcome measure used to evaluate the efficacy of anoestrus cow management was the timing of anoestrus intervention relative to MSD. In addition, the proportion of cows treated for anoestrus was calculated for each herd. Herds with no anoestrus treatments recorded were excluded from the analysis. Where bulls had been used to mate anoestrus cows before or at MSD, these herds were also excluded from this analysis. The first treatment date in each study-year was defined as the anoestrus intervention date for that herd-year. Treatment prior to MSD was regarded as preferable to treatment after MSD (McDougall, 2010b). Anoestrus intervention date was categorised as either early (before MSD) or late (on or after MSD). Timing of anoestrus intervention date relative to MSD in both 2009/10 and 2010/11 was compared between treatment and control groups.

Anoestrous cow management was covered in the InCalf Farmer Action Group as the second of two topics in the submission rate topic during the Mating prepare meeting (Figure 5.1). The association between intention to modify anoestrous cow management and this measure in both 2009/10 and 2010/11 was also assessed.

5.3.9. *Bull management*

Bull management was assessed in each herd-year as a ratio of the mean of discrete time hazards of conception for each week in the three weeks following the end of the artificial insemination period, when bulls were run with the lactating herd (the bull period) to that for the three weeks preceding the end of artificial insemination period (Bull management ratio). Hazards were derived for each week using conception dates established through rectal pregnancy diagnosis and the mean hazard for each three week block calculated. The ratio of the mean hazards was then calculated:

$$Bull\ management\ ratio = \frac{mean\ of\ weekly\ hazard\ of\ conception\ post\ start\ of\ bull\ period}{mean\ of\ weekly\ hazard\ of\ conception\ pre\ start\ of\ bull\ period}$$

Each of these weekly hazards describes the probability of conception occurring in the week amongst cows that were not pregnant at the start of the week. For example, based on subsequent pregnancy test results, there were 300 cows not pregnant at the start of the third week preceding the end of the artificial insemination period, and 30 of these cows became pregnant during that week. Then the hazard of conception in that week was 10% (30/300). Where sensitivity of oestrus detection is high and anoestrus prevalence in the three weeks preceding the end of the artificial insemination period is low but bull management is very poor, a hazard ratio markedly lower than 1 would be expected. Ratios for each herd-year were categorised as <0.88 (suggestive of poor bull management) or ≥0.88 since this was the mean bull management ratio. The mean bull management ratio of the control group herds was chosen retrospectively as the cut point rather than a cut point of 1. These ratios would have had random variation so an observed value just below 1 may not be due to poor bull management, furthermore, the hazard of conception would be expected to decline as the mating period progresses, as infertile cows constitute an increasing proportion of the non-pregnant population.

In addition, data on the maximum number of bulls used at any one time for breeding was collected at pregnancy diagnosis visits and described. From these data, the overall cow to bull ratio (cows in herd to maximum bull number used at any one time) and the adjusted ratio of cows to bulls (using the estimated number of cows that were not pregnant on day 42 (i.e. at the end of the 6th week) of the breeding program (calculated retrospectively based on conception estimates from pregnancy testing) were calculated.

Categorised ratios in both 2009/10 and 2010/11 were compared between treatment and control groups. Bull management was addressed in the InCalf Farmer Action Group Mating prepare session (Figure 5.1). The association between intention to modify bull management and the bull management ratio in 2010/11 was assessed.

5.3.10. *Overall effect of proposing actions on improving herd reproductive performance*

The association between the total number of key management topics that had at least one action proposed was assessed against the 6 week in-calf rate in the 2010/11 study-year.

5.3.11. *Statistical analyses*

All data were transferred to Stata Version 12 (StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp SE.) for analyses. Data were analysed at herd-year level (when measures for 2009/10 and 2010/11 were pooled) or at a herd level (when only measures for 2010/11) were analysed.

5.3.12. *Effect of farmer participation in an InCalf Farmer Action Group on key management factor*

To determine the effect of participation in the InCalf programme the following models were used. Where the key management factor measures (the outcome variable) were proportions these were modelled using generalised linear regression models with logit link functions and binomial error distributions using -binreg- in Stata. Continuous outcome variables were analysed using ordinary linear regression models. For binary outcome variables (anoestrus intervention date and the bull management ratio) logistic regression was used.

Where outcome measures were analysed at herd-year level, in which case each herd could contribute two observations, robust standard errors were used (with -binreg-) to account for the repeated measures within herds or random effects of herd were fitted (ordinary linear regression and logistic regression). Where outcome measures were analysed at a herd level using the 2010/11 study-year data, the corresponding 2009/10 data were incorporated as covariate to account for potential confounding of preceding performance on 2010/11 outcome. This was reported where significant at a p=0.05 level. Estimated marginal means were derived from models using Stata's margins command where appropriate. Only associations between group (treatment or control) and key management factors that were significant at the p=0.05 level are reported.

To account for the subjective nature of body scoring undertaken by technicians specific to each region, region was included as a covariate in models analysing BCS. It was not included in other management factors as other measures were considered more objective.

5.3.13. *Association between intention to change and herd performance for the key management factor*

Within the treatment group, associations between intention to change management and 2010/11 key management factor measures were examined using the same models proposed previously. Proposed actions were categorised into similar themes and associations of proposing at least one action and associations of individually proposed actions with the key management factor were examined. The corresponding 2009/10 measure was included as a continuous independent variable to account for potential confounding due to farmers in herds with poorer performance for the key management factor being more likely to intend to change management behaviour(s) (Vickers, 2001). Only associations that were significant at the p=0.05 level are reported. Where farmers reported not enacting an action, responses to review session questions reasons for not enacting the proposed actions were reported qualitatively.

The association between the total number of key management topics that had at least one action proposed was assessed against the 6 week in-calf rate in the 2010/11 study-year using a generalised linear regression model using the -binreg- function, incorporating the preceding 2009/10 6 week in-calf rate as a covariate.

5.4. Results

Of the 63 KDM of herds allocated to the treatment group and used in analyses, one or more KDM from 62 herds (98%) attended the calving prepare meeting, KDM from 62/63 herds (98%) attended the mating prepare meeting, KDM from 57/63 herds (90%) attended the mid/late lactation prepare meeting and KDM from 55/63 herds (87%) attended the dry period prepare meeting. KDM from only 38/63 herds (60%) attended all four meetings.

5.4.1. *Calving pattern*

5.4.2. *Effect of KDM participation in an InCalf Farmer Action Group on calving pattern*

There was no difference in the percentage of cows that calved <42 days after PSC in the 2010/11 study-year between treatment and control groups (p=0.63 Table 5.2). However, a greater proportion of heifers calved <42 days after PSC in 2010/11 in the treatment than control herds (p<0.001). Other determinants of the 2010/11 calving pattern did not differ significantly between treatment and control herds (p>0.2; Table 5.2).

Table 5.2. Marginal mean (standard error: SE) estimates of calving pattern and some key determinants of calving pattern by treatment group for seasonal-calving pasture-based herds enrolled in the New Zealand National Herd Fertility Study

	Estimated marginal means (SE)		
Variable	**Control**	**Treatment**	**p -value**
Calving pattern[a]	83.3 (5.9) %	86.7 (4.8) %	0.63
Culling[b]	20.6 (18.7) %	25.2 (18.4) %	0.78
Induced[c]	65.6 (20.0) %	68.9 (20.7) %	0.79
Purchased cows' calving pattern[d]	67.3 (31.0) %	83.8 (20.5) %	0.22
Heifer calving pattern[e]	89.1 (8.6) %	93.2 (3.5) %	<0.01

[a] Proportion of calvings in the 2010/11 study-year that occurred on or before day 42 after the planned start of calving (PSC) ('early' calvings)

[b] Of cows that were diagnosed as conceiving late in 2009/10, the percentage that were culled before the 2010/2011 calving period

[c] Of cows that were diagnosed as conceiving late in 2009/10, percentage that were induced to calve early in the 2010/2011 calving period in herds that induced at least one cow

[d] Of herds that purchased cows, percentage of cows that were purchased soon before the 2010/11 calving period with calvings that occurred early in the 2010/2011 calving period

[e] Percent of calvings of heifers in the 2010/2011 study-year that were early calvings

5.4.3. *Intended changes by KDMs in management behaviours associated with calving pattern*

The management of calving period duration in the 2010 calving period was discussed at the calving prepare session in June/July 2009. At this session, KDMs from 53 of these 62 herds (85%) proposed an action to improve performance. The most common proposed actions were to introduce increased staff training (18 (29%) of the 62 attending herds) and earlier induction of premature calving (17 (27 %)/62; Table 5.3).

Table 5.3. Numbers (n) and percentages of 62 and 55 herds enrolled in an InCalf Farmer Action Group where one or more KDM from each herd attended the calving and drying-off prepare meetings, respectively, and proposed actions in response to dissatisfaction with their herd's calving pattern categorised by framework of calving or drying off prepare meeting and theme of action

	Category of proposed action	Calving prepare meeting (n=62)		Dry period prepare meeting (n=55)	
Framework of meeting	**Proposed action**	**n**	**%**	**n**	**%**
That everyone understands the importance of maximising the number of cows that calve in the first six weeks					
	Undertake staff education	18	29%	6	11%
	Use InCalf tool	5	8%	3	5%
	Set standard operating procedures or targets	2	3%	8	24%
That you have a 'due to calve' list to assess your upcoming calving pattern vs. targets?					
	Print off report from herd recording software	12	19%	14	25%
That you are planning and managing the following most effectively to achieve your desired calving pattern:					
Culling of late calving cows	Identify and remove late calving cows	10	16%	19	35%
Buying of early calving cows	Preferentially buy early calving cows	4	6%	2	4%
Calving induction (where used)	Induce late calving cows earlier in calving period	17	27%	11	20%
	Make a plan	11	18%	5	9%
	Reduce inductions	3	5%	4	7%
Heifer management	Set targets for weight/BCS	11	18%	8	15%
	Bring mating date forward	5	8%	1	2%
	Increase bull power	1	2%	2	4%
	Hormonal synchronization	1	2%	14	25%

Of the 62 KDMs that attended the calving prepare session, 56 attended the corresponding calving review session. KDMs from 30 of those 53 herds that had proposed actions (57%) indicated that they had wholly enacted them, 24 indicated that they had partially enacted and 2 had not enacted their plans. One attendee indicated that the non-compliance was due to decision making being out of their control (staff attending in place of the KDM), the second gave no reason.

KDM from 46 of the 63 treatment herds (70%) attended the dry period prepare session and 42 (91%) proposed at least one action. Of these 46 herds, KDMs from 40 (87%) also attended the corresponding dry period review session. KDMs from 20 of these 40 herds (50%) reported that they wholly enacted their proposed actions, while 15 (32%) and 5 (10%), respectively, partially enacted or failed to enact their proposed actions. KDM that failed to enact actions reported purchasing late calving cows as reasons for failure.

After the dry prepare session, 8/55 (15%) KDM proposed to set targets/generate standard operating procedures compared with 2/62 (3%) after the calving prepare session. In addition, 14/55 (25%) proposed to synchronise their heifer matings with hormonal interventions after the dry session compared with 1/62 (2%) after the calving session.

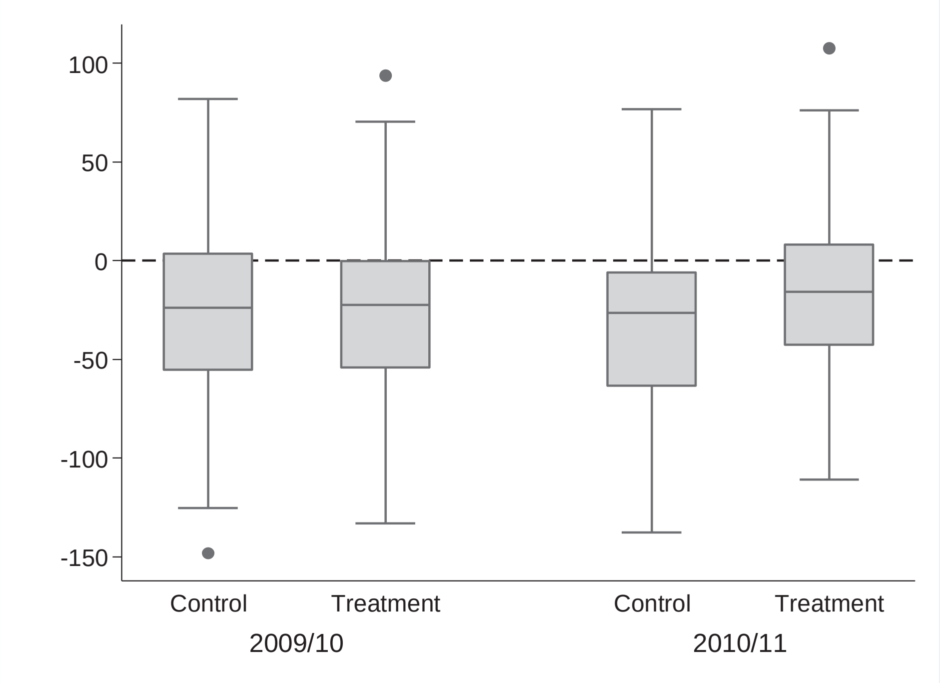
5.4.4. *Association between intention to change and calving pattern*

There was no association (p=0.99) between intention to change management of calving pattern (i.e. KDM proposing one or more actions in either the calving or dry period prepare session) and the proportion of cows that calved <42 days after PSC in 2010/11.

5.4.5. *Heifer precalving live-weight*

In total, 7,926 and 6,711 precalving heifer weights from 119 and 114 herds were recorded in the 2009/10 and 2010/11 study years, respectively. Of those, 85% (6,711) and 91% (6,118) heifer weights from these herds had identification that could reliably be matched to live-weight breeding values in the National Dairy Database in 2009/10 and 2010/11 study years, respectively, and were analysed in this study. Means of herd average heifer live-weights in the control group in the 2009/10 and 2010/11 study years were 428kg (SD of herd means 46kg) and 416kg (SD of herd means 65kg), and the means of mean weight-gaps were -28kg (SD of herd means 47kg) and -33kg (SD of herd means 45kg), respectively.

a.



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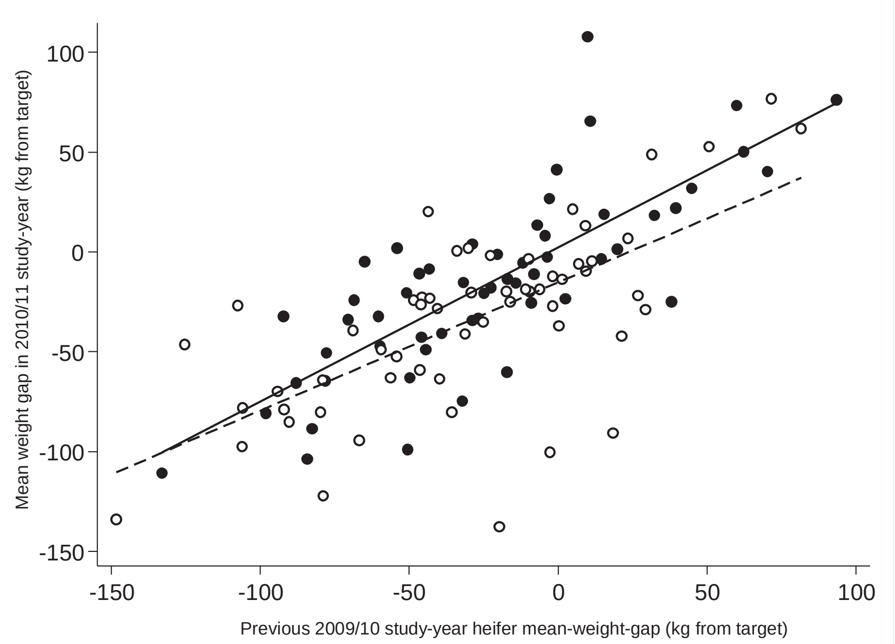

Figure 5.2.a, Box and Whisker plot of mean-weight-gap by season and treatment group and b, scatter plot of raw mean-weight-gap (mean of measured live-weight minus estimated target live-weight for 70 randomly selected heifers) in 59 herds allocated to treatment group (InCalf Farmer Action Group) represented by black dots (●) and 60 herds in the control group represented by open dots (○) for the 2009/10 against the 2010/11 study year. Line of best fit represents treatment (solid line) and control group herds (dashed line)

5.4.6. *Effect of KDMs participation in an InCalf Farmer Action Group on heifer precalving live weight*

Participation in the InCalf programme was associated with 17kg (SE=8.5kg) less mean weight gap in the 2010/11 study year than found in control herds (p=0.048). When the mean-weight-gap of the preceding 2009/10 study year was incorporated, the model fit for the effect of treatment was improved (p<0.001). Figure 5.2 shows the relationship between the live-weight-gap of the two study years. There was no significant interaction between treatment group and mean-weight-gap from the preceding 2009/10 study-year (p=0.16).

5.4.7. *Intended changes by KDMs in management behaviours associated with heifer precalving live-weight*

Of the 57 KDM that attended the heifer management session, 52 (91%) proposed one or more action(s) (Table 5.4).

Table 5.4. Numbers (n) and percentages of the 57 herds enrolled in an InCalf Farmer Action Group where one or more KDM from each herd attended the mid/late lactation prepare meeting and proposed actions in response to dissatisfaction with current heifer live weight management categorised by framework of prepare meeting and theme of action

Framework of meeting	Category of proposed action	n	%
That everyone on your farm understands the importance of ensuring heifer management stays on track			
	Revise agreements with grazier	14	25%
	Undertake staff training	23	40%
	Use InCalf tool	11	19%
That you have set heifer live weight targets that suit your herd			
	Acquire LwtBVs[a] to set targets	26	46%
	Weigh adult cows to set own targets	10	18%
That you are measuring heifer live weights and comparing them with your targets often enough to make changes quickly if heifers go off track			
	Weigh or weigh more frequently	30	53%
	Weigh and use set targets	7	12%
That you know what to do to achieve your heifer live weight targets			
	Health plan/grazing plan	8	14%

[a] LwtBV = genetic breeding values for live-weight value

5.4.8. *Association between intention to change and heifer precalving live-weight*

While accounting for 2009/10 mean-weight-gap, KDM that intended to modify heifer management had on average 20kg smaller mean-weight-gap than those not intending to change heifer management in the 2010/11 study-year (Table 5.4; p=0.02). When each proposed action was assessed individually, 'revise agreements with grazier' was associated with the largest reduction in mean-weight-gap relative to herds with no proposed action (26kg mean reduction in gap, p=0.01).

Of KDM that attended the heifer management prepare session, 47/57 (90%) attended the corresponding review session and reviewed their actions. Actions were fully enacted by 17 KDM, 17 KDM partially enacted their actions and 13 (28%) did not enact any intended actions. Five of these reported not finding the facilities to weigh heifers, one failed to undertake replacing ear tag identification and one experienced resistance from their current grazier to monitoring methods; the remainder gave no explanation.

5.4.9. *Body condition score and nutrition*

In total, 10,466 and 9,296 precalving body condition scores were undertaken in 134 and 128 herds and 12,002 and 10,655 pre-mating body condition scores were undertaken in 132 herds during both the 2009/10 and 2010/11 study years, respectively. Following cow and herd exclusions (Figure 4.2), 8,447 and 7,834 precalving body condition scores from 120 and 117 herd were analysed, as were 10,217 and 9,369 pre-mating body condition scores from 117 and 120 herd from the 2009/10 and 2010/11 study-years, respectively. Due to apparent technician measurement error in pre-mating BCS in the 2009/2010 study-year in the Taranaki region (Figure 5.3), these data were excluded from analyses (Table 5.5).

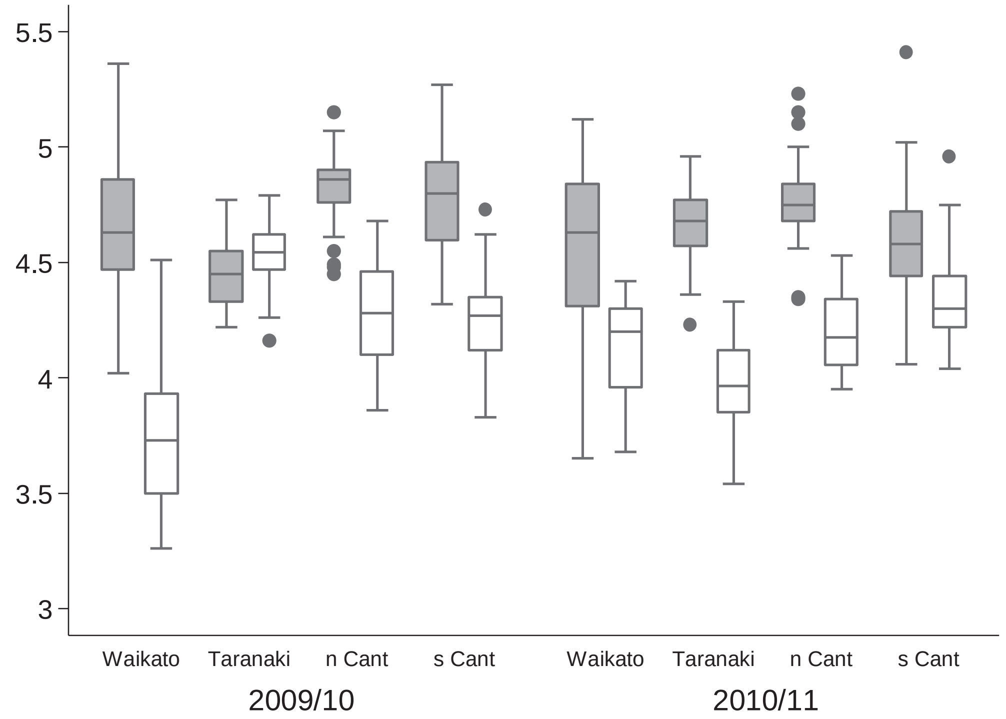

Figure 5.3. Box plot of precalving (grey) and pre-mating (open) herd mean body condition scores of seasonal-calving pasture-based herds enrolled in the New Zealand National Herd Fertility Study for two study years (2009/10 and 2010/11) and by region (n Cant = North Canterbury and s Cant = South Canterbury). The box represents the distribution of the 25th to 75th percentiles and the line represents the 5th and 95th percentiles. The midline represents the median of the distribution. And closed dots (●) represent outliers.

Mean precalving BCS declined amongst control herds between the 2009/10 and 2010/11 study-years (Table 5.5). There was a significant regional difference between marginal mean estimates of precalving BCS that could be attributed to the use of one technician within each region. Mean regional scores for pooled study-years in the control group were 4.55 (SE 0.05), 4.75 (SE 0.04) and 4.67 (SE 0.05) for the Waikato, north Canterbury and south Canterbury, respectively ($p<0.01$). On average, 54% (SD 21%) of a control herd was below precalving BCS target and 3% of a herd exceeded the upper precalving target across pooled study-years.

Mean premating BCS increased from 4.07 (SE 0.04) in the 2009/10 to 4.17 (SE 0.03) in control herds in the 2010/11 study-year. There was significant difference in regional pre-mating estimates with scores of 3.86 (SE 0.04) 4.19 (SE 0.04) and 4.34 (SE 0.04) for the Waikato, North Canterbury and South Canterbury, respectively ($p<0.01$). The difference among the control herds in mean BCS between calving and mating pooled for both study-years was 0.53/10 (SD 0.35). On average 62% (SD 23%) of a herd was below pre-mating target BCS.

5.4.10. *Effects of KDM participation in an InCalf Farmer Action Group on body condition score*

Treatment was not associated with a difference in precalving BCS in the 2010/11 study-year or the proportion of the herd not meeting target condition scores, after accounting for region. Treatment was associated with higher mean premating BCS compared with control herds in the 2010/11 study-year (p=0.01) but not in the 2009/10 study-year (p=0.99). A higher proportion of cows met premating BCS targets in treatment than control herds (p=0.01; Table 5.5).

Table 5.5. Mean (±SE) of herd mean body condition score (1 to 10 scale) or proportion for 70 randomly selected cows from dairy herds from three regions (excluding Taranaki) enrolled in the New Zealand National Herd Fertility Study by study-year and treatment group

	2009/10					2010/11				
	Control		Treatment			Control		Treatment		
	n[a]	BCS (±SE)	n	BCS (±SE)	p-value[b]	n[a]	BCS (±SE)	n	BCS (±SE)	p-value[b]
Mean BCS precalving (/10)	45	4.72 (±0.22)	44	4.77 (±0.30)	-	45	4.61 (±0.32)	42	4.67 (±0.29)	0.19
Mean proportion ≤4.5 precalving	45	0.52 (±0.19)	44	0.45 (±0.24)	-	45	0.56 (±0.24)	42	0.50 (±0.21)	0.23
Mean proportion ≥5.5 precalving	45	0.03 (±0.04)	44	0.04 (±0.05)	-	45	0.03 (±0.04)	42	0.03 (±0.04)	0.42
Mean BCS premating (/10)	45	4.07 (±0.39)	42	4.07 (±0.33)	0.99	47	4.18 (±0.20)	43	4.28 (±0.23)	0.01
Mean proportion ≤3.5 premating	45	0.63 (±0.27)	42	0.63 (±0.24)	0.94	47	0.61 (±0.18)	43	0.50 (±0.17)	0.01
Change in body condition score between calving and mating[b]	43	0.64 (±0.36)	42	0.70 (±0.37)	0.57	45	0.43 (±0.32)	41	0.39 (±0.30)	0.46

[a] Total number of herds condition scored in each treatment group and study-year

[b] Significance test of difference between treatment groups accounting for region using linear regression; 2009/10 precalving not tested since exposure to treatment too early for hypothesised effect

5.4.11. *Intended changes by KDMs in management behaviours associated with precalving and premating body condition score*

Body condition score and nutrition was considered in each of the four prepare meetings. In these 53/62 (85%), 50/62 (80%), 47/57 (82%) and 42/55 (76%) of farmers proposed at least one action to improve BCS management (Table 5.6).

5.4.12. *Association between intention to change and precalving and premating body condition score*

Overall there was no association between proposing actions and a change in precalving or premating BCS in the 2010/11 study-year when accounting for the 2009/10 outcome (p>0.05). However, in all cases a positive relationship existed between the intention to modify behaviour and outcomes. The intention to undertake regular nutritional checks was associated with a reduced loss in BCS between calving and mating (p<0.001). In total, 9 (2.8%) of all 380 actions proposed were not enacted by KDM; eight KDM reported that proposed nutritional checks were not undertaken and one implicated poor weather for loss of cow BCS.

Table 5.6. Numbers (n) and percentages of the 63 herds enrolled in an InCalf Farmer Action Group where one or more KDM from each herd attended one or more meetings and proposed actions in response to dissatisfaction with current cow body condition categorised by framework of each prepare meeting and theme of action

Framework of meeting	Calving prepare meeting (n=62)		Mating prepare meeting (n=62)		Mid/late-lactation prepare meeting (n=57)		Dry period prepare meeting (n=55)	
Category of proposed action	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
That everyone on the farm understands the importance of managing herd nutrition								
Staff meeting/training	26	42%	22	35%	20	35%	16	29%
That you are using appropriate feeding or other strategies to avoid excessive loss of body condition as cows approach peak lactation								
Monitor cows	10	16%						
Monitor nutrition	15	24%						
That you are effectively monitoring body condition and using appropriate feeding and drying off strategies to improve BCS								
Condition score					30	57%	24	44%
Once daily milking/Dry off on BCS					10	18%	5	10%
Feed preferentially					2	4%		
That quick checks are being made routinely that will alert you to herd nutritional problems before cows lose excess body condition								
Monitor quick checks	23	37%	42	67%	29	51%		
Monitor BCS alone			1	2%				
That, if problems are identified, quick action is taken to make appropriate adjustments								
Reactive plans	4	6%	25	40%	12	21%	8	15%
Preventative plans	8	13%	4	6%	16	21%	3	5%
That your nutrition programme for dry cows during their last 2-3 weeks before calving is preparing them well for the coming lactation								
Introduce transition diet							19	35%
Trace element work-up							6	11%

5.4.13. *Oestrus detection*

Amongst control herds, the average early-calved mature cow 3 week submission rate was 85.0 (SD 7.4) % in 2009/10 and 86.0 (SD 8.1) % in 2010/11.

5.4.14. *Effect of KDM participation in an InCalf Farmer Action Group on oestrus detection*

Treatment herds had a mean 3.4% higher 21 day submission rate than control herds in 2009/10 ($p<0.01$), and had a mean 2.3% higher rate in 2010/11 ($p=0.8$). When the study-years were pooled, the estimated 21 day submission rate for treatment and control herds was 88.4% (SE 0.5%) and 85.5% (SE 0.8%) respectively ($p<0.01$); an overall risk difference of 2.9%.

5.4.15. *Intended changes by KDMs in management behaviours associated with oestrus detection*

In total, 48/62 (77%) farmers attending the mating prepare session indicated dissatisfaction with their management of oestrus detection and proposed at least one action to improve performance (Table 5.7). Of those, 25 (52%) proposed more than one action.

Table 5.7. Numbers (n) and percentages of 62 herds enrolled in an InCalf Farmer Action Group where one or more KDM from each herd attended the mating prepare meeting and proposed actions in response to dissatisfaction with oestrus detection and/or anoestrus cow management categorised by framework of prepare meeting and theme of action

Framework of meeting	Category of proposed action	n	%
Everyone on the farms knows how to accurately detect cows on heat			
	Staff meeting	26	42%
	Sole responsibility	7	11%
	Staff training	3	5%
That the use of heat detection aids and paddock checks are maximising the number of cows detected on heat			
	Paddock checking	21	34%
	Improve heat detection aid use	16	26%
	Other management plans	7	11%
That you are addressing all the factors that affect the number of non-cyclers in your herd			
	Vaginal diagnosis of endometritis (Metricheck)	10	16%
	Identify and preferentially treat/feed skinny cows	14	23%
	Other management plans	10	16%
That you are identifying and effectively managing you non-cyclers before PSM?			
	Treat non-cyclers early - discuss with vet	14	23%
	Heat detection aids	8	13%
	Identify and preferentially treat/feed skinny cows	6	10%
	Other management plans	3	5%

5.4.16. *Association between intention to change and oestrus detection*

Neither proposing an action nor any specific action was associated with a change in 21 day submission rate in the 2010/11 study-year ($p>0.05$).

5.4.17. *Anoestrus cow management*

5.4.18. *Effect of KDM participation in an InCalf Farmer Action Group on anoestrus cow management*

Hormonal anoestrus treatment were recorded in 53/126 (42%) of herd-years in the control group and 55/120 (46%) of herd-years in the treatment group. In the 2009/10 study-year, 12 of 26 herds in the control group first treated anoestrus cows in advance of MSD compared with 21 of 27 treatment herds. Conversely, 19 of 28 herds in the control group treated anoestrus cows in advance of MSD compared to 15 of 27 herds in the treatment group in the 2010/11 study-year. An interaction between treatment and study-year indicated an increasing number of control herds and fewer treatment herds intervening before MSD in the 2010/11 study-year than in the 2009/10 study-year (p = 0.02). When study years were pooled, allocation to treatment had no significant effect on the overall likelihood of anoestrus treatment occurring in advance of MSD (p=0.35).

5.4.19. *Intended changes by KDMs in management behaviours associated with anoestrus cow management*

Of the farmers attending the prepare session, 47/48 (98%) expressed dissatisfaction with their management of anoestrous cows and proposed at least one action to improve management (Table 5.7). Of those, 35 indicated that they had complied either wholly or partially with their proposed actions at the corresponding review session.

Table 5.8: Numbers (n) and percentages of the 62 herds enrolled in an InCalf Farmer Action Group where one or more KDM from each herd attended the mating prepare meeting and proposed actions in response to dissatisfaction with current bull mating management categorised by framework of prepare session and theme of action

Framework of meeting	Proposed action	n	percentage
That you are selecting healthy, fertile, well grown bulls to run with your herd?			
	Fertility check/health certificates	25	40%
	Care around bull breed/age choice	5	8%
That your day-to-day management of working bulls ensures maximum bull activity?			
	Leave bulls in paddocks	12	19%
	Rotate teams	9	15%
	More bulls to relieve pressure	6	10%
That enough bulls are available when cows are likely to be on heat?			
	Calculate and meet bull requirements	29	47%
That your chosen length of total mating period will enable you to achieve your desired empty rate?			
	Calculate desired length	9	15%
	Reduce mating length	7	11%
	Increase mating length	2	3%

5.4.20. *Association between intention to change and anoestrus cow management*

Since almost all KDMs proposed actions, meaningful comparison between those intending to change any management behaviour and other herds in the treatment group were not possible. Individually, no category of intended action was significantly associated with recorded anoestrus treatment before (rather than on or after) MSD (p>0.05) amongst herd-years where anoestrus treatments were recorded.

5.4.21. *Bull management*

One of 123 herds used artificial insemination only in both study years and was excluded from this analysis. The remainder of herds operated a natural (bull) mating period with an overall mean duration of 53 (SD ±14) days in both study seasons. Bulls were introduced to the herds on average 42 (SD ±10) days after the MSD in both treatment groups. The mean cow to bull ratio was 66:1 (SD ±23 cows) and the mean adjusted ratio of cows to bulls (using the estimated number of cows that were not pregnant on day 42 of the mating period) was 21:1 (SD ±10 cows). Mean bull management ratio among control herds was 0.84 (SD=0.23) in the 2010/11 study-year and 0.91 (SD=0.37) in the 2010/11 study year.

5.4.22. *Effect of KDM participation in an InCalf Farmer Action Group on bull management*

Treatment did not alter the hazard ratio of conception during the bull mating period relative to the AI period (p=0.43).

5.4.23. *Intended changes by KDMs in management behaviours associated with bull management*

Actions were proposed by 52/62 (83%) of farmers that attended the mating prepare session. Of those, 36/62 (58%) proposed more than one action (Table 5.8). At the subsequent review session, 29/51 (57%) indicated that they had successfully complied with their intended actions and 17 (33%) had partially complied. Five had failed to undertake the actions; of these, two reported failing to retain bulls in paddocks when removing the herd for milking and one reported not purchasing enough bulls. The remainder gave no reason.

5.4.24. *Association between intention to change and bull management*

No intended actions were significantly associated with the difference in hazard ratio between seasons (p>0.05).

5.4.25. *Overall effect of proposed actions to the InCalf Farmer Action Group on* 6 week in-calf rate

The mean percentage of farmers attending all InCalf Farmer Action Group meetings was 60%, with the highest attendance in South Canterbury (13/15; 87%) and the lowest attendance in North Canterbury (6/12; 50%). On average, farmers proposed actions in eight of the ten topics, with a range of four to ten actions proposed. Where the total number of topics where a KDM had proposed at least one action was regressed against the 6 week in-calf rate in the 2010/11 study-year, a negative relationship was found (Figure 4; p=0.01). An interaction between outcome variable and pre-enrolment 6 week in-calf rate was untestable due to sample size.

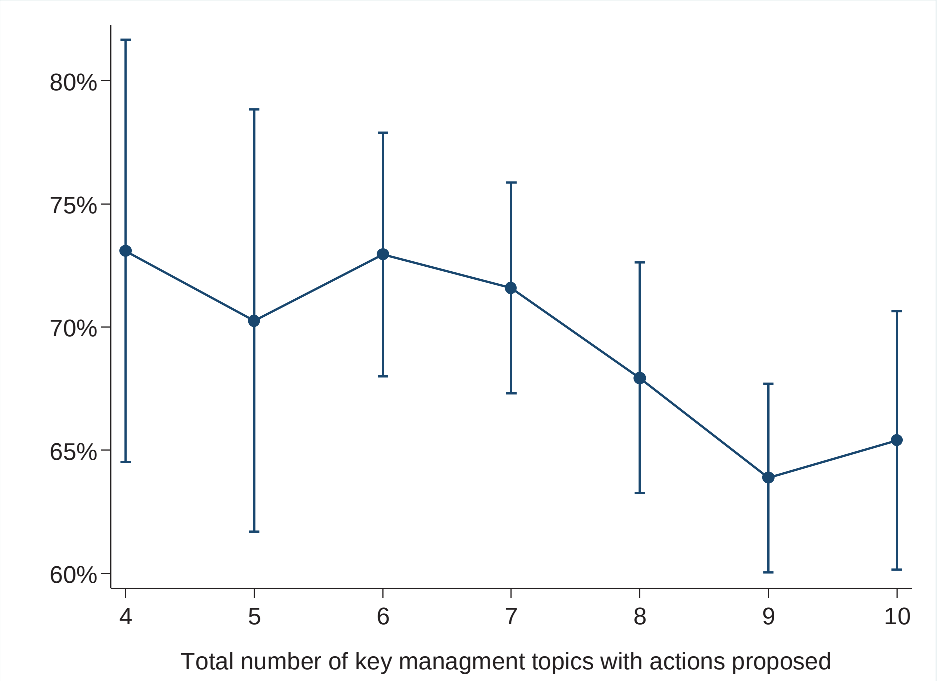

Figure 5.4. Marginal mean estimate (95% CI) of the percentage of cows that conceived in the first 42 days of the 2010/11 mating period (6 week in-calf rate) by the total number of key management topics? that KDM proposed at least one action as a result of participation of an InCalf Farmer Action Group. The preceding 2009/10 6 week in-calf rate was incorporated as a covariate in the multivariate model to account for potential interaction of preceding performance on proposal of actions

5.5. Discussion

The results of this study show that involvement in the InCalf Farmer Action Group can improve several key risk factors for reproductive performance. However, the success of the programme did not apparently depend on the process of farmers proposing or undertaking actions. Herds in the treatment group that achieved the highest 6 week in-calf rate in the 2010/11 study-year proposed fewer actions than herds that achieving lower 6 week in-calf rates.

A high level of dissatisfaction was expressed by farmers towards all risk factor topics. The highest number of KDM (58 of 63; 92%) expressed dissatisfaction with at least one aspect of their calving pattern, while least (47/63; 75%) expressed dissatisfaction about the condition score of their herd. However, during interviews at the outset of the study, over 50% of KDM enrolled in both treatment and control groups indicated that they were satisfied or very satisfied with the overall reproductive performance of their herds (Chapter 2). This suggests that an association between KDM perception of overall reproductive performance and perception of risk factor performance is not strong. Strong relationships between these key risk factors and overall reproductive performance have been identified consistently (Macmillan, 2002a, b; McDougall, 2006; Morton, 2003b). A high level of dissatisfaction with overall performance is regarded as important to induce change (Holifield and Masters, 1993) but dissatisfaction with the performance of key risk factors is considered necessary to drive change. Attitude-behavioural change models such as the theory of planned behaviour (Ajzen, 1991a) hypothesise that critical attitudes increase with the specificity of a behaviour (Wicker, 1969). This might provide a plausible explanation for this apparent paradox in attitudes; attitude towards overall reproductive performance would only weakly predict whether specific risk factors were satisfactory whereas specific attitudes have much stronger associations with specific risk factors.

Central to attitude-behavioural change models is the key role of intention. Intentions are described as self-instructions to perform particular behaviours (Triandis, 1980) and usually follow deliberation about what one would do or how hard they were prepared to work in order to achieve it (Webb and Sheeran, 2006). The InCalf Farmer Action Group process of ‘plan-do-review’ relied on KDM intention to change behaviour. Within the facilitated prepare sessions, KDM were challenged on specific on-farm behaviours (e.g. *how satisfied are you that everyone on the farm understands the need to achieve a high proportion of early calving cows?*) and following deliberation, proposed intentions to modify management behaviour if not satisfied (*e.g. arrange weekly farm meetings every Tuesday morning to discuss weekly farm management issues*). A randomised controlled study design allowed the overall effect of participation in the treatment to be measured on each of the risk factors measures. Considerable variation existed in actual biophysical risk factor measures between farms, inferring that there was pre-study variation in management behaviours on farm. The intentions to change behaviour brought about by the Farmer Action Group however, were intrinsic to the treatment and analysed within the treatment group alone.

A positive effect of participation in the InCalf Farmer Action Group was found on heifer live weights, mean premating BCS, proportion of treatment herds meeting premating BCS targets, and oestrus detection. No significant difference was found between treatment groups in measures of calving pattern, anoestrus cow management or a bull management ratio in the 2010/11 study year. The association of each of these factors with overall reproductive performance (6 week in-calf rate) is not likely to be the similar. Calving pattern will have a stronger relationship than bull management for example. Few herds had artificial breeding periods short enough for bull management to affect 6 week in-calf rate. Bull management would, however, have an important effect on final not-in-calf rate.

The key management factors that are prioritised by InCalf were accepted from the Australian Dairy Herd Fertility Project conducted in 2000 (Morton, 2004) and while there is a generous body of evidence that supports each of these as risk factors for performance, no work has been undertaken to identify putative risk factors in New Zealand. Several other potential risk factors, including genetic selection for production, endemic infectious disease and uterine health issues, have been suggested (Baudracco *et al.*, 2011; Heuer *et al.*, 2007; McDougall, 2001b) and their contribution to reproductive performance needs to be evaluated.

The review process allowed critical assessment of actions proposed in the first year and further modification of intentions based on the experience of enacting the actions. In the seasonal-calving dairy system, the results of modifications should be measurable in the subsequent season. Where exposure to relevant aspects of management planning for the treatment group occurred before measures could be made, the effect was measured in the subsequent (2010/11) season. The management factor performance in the year of treatment was included to account for the potential confounding effect of prior knowledge of performance. This was preferred to ignoring this effect and pooling the outcome measures. It is feasible that benefits beyond the two years analysed in the current study accrue after involvement in farmer action groups. Further years need to be examined to evaluate the longevity of the effect of treatment.

Not all treatment group herds made a positive change, while some control group herds made management changes independent of the study. Changes in management behaviour independent of those proposed in the Farmer Action Group needs to examined, as it was feasible that influential changes in management occurred and may not have been recognised or declared in the review sessions. Some of this data exists in the annual KDM interview, but remains to be analysed.

While accounting for the preceding performance, herds in the treatment group that proposed five or fewer actions had better performance in the 2010/11 study-year than herds that proposed six or more actions. This finding contradicts findings by Green *et al.* (2007) where a randomised controlled study was used to evaluate the implementation of a mastitis control programme in British dairy herds. This British study found that compliance to a greater number of management changes, and the motivation to do this, were critical to the success of the intervention. Individual management changes alone however, were not significantly associated with changes in the incidence of mastitis and this led the authors to suggest that management change may have to be cumulative in order to create a significant difference in incidence of clinical mastitis or bulk milk tank somatic cell count. A greater number of proposed actions were not associated with an improvement in overall reproductive performance in the current study; however involvement in the programme had a positive effect on reproductive performance. This study differed from the British study in a number of ways; critically, the proposed actions were suggested by the same KDM enacting the actions, whereas the actions in the British study were recommendations from one of two impartial mastitis specialists and the British study monitored the compliance to those recommendations. This might imply that the actions proposed in the InCalf Farmer Action Group by KDM alone are not as effective as advice from independent advisors and since few proposed actions fulfilled the S.M.A.R.T. criteria, a different advisor based approach (e.g. one-on-one consultancy) would be better suited to developing effective action plans.

Overall, participation in the InCalf Farmer Action Group was found to improve the performance of three known key management factors that affect reproductive performance during the subsequent one or two years. Further work is needed to understand where improvements can be made in the InCalf program to ensure change in the remaining management factors and as to whether more influential management factors than those examined exist. Within the InCalf Farmer Action Group the majority of farmers expressed dissatisfaction with specific management practices. However, the process of written intentions to change these practices was not associated with this improvement. A more effective strategy to ensure S.M.A.R.T. objectives are proposed should be investigated to improve the programme further.

CHAPTER 6

General Discussion

6.1. Introduction

The aims of this thesis were to (i) benchmark the current herd-level reproductive performance of a representative sample of pasture-based, seasonal-calving dairy herds from four regions of New Zealand and to (ii) quantify the effect of participating in the InCalf reproductive extension programme within this group.

The work presented in the previous chapters has established a baseline herd-level description of reproductive performance and farmer attitudes towards reproductive management, identified bivariate associations of these descriptions with common biophysical and socio-demographic factors and quantified the effect of the InCalf Farmer Action Group on herd-level reproductive performance and management factors known to drive reproductive performance.

The thesis began with a review of published experience of the evolution and evaluation of extension and put it in context of the New Zealand dairy industry.

The individual studies conducted to fulfil the aims of the thesis were prepared as papers for submission to refereed scientific journals and referenced existing knowledge in each discussion. Therefore, in this concluding chapter, the methodology and results of the thesis are considered with suggestions for how they could have been enhanced. The findings from individual chapters are then discussed in context of a path to improving overall reproductive performance on-farm. The chapter concludes with a discussion of the implications and recommendations of the findings of the thesis for the New Zealand dairy industry followed by suggestions for future work.

6.2. Overall review of study design

A single large-scale study design was the foundation for all work in this thesis. This study was the first randomised control trial (RCT) undertaken in New Zealand to quantify the effect of an agricultural extension programme and is most likely only the third RCT undertaken internationally (Bell *et al.*, 2009; Green *et al.*, 2007). The study appears to be the first to assess an extension program designed to improve reproductive performance of dairy herds. In this context, this was a novel study.

6.2.1. *Hierarchy of data*

The reproductive data collected in this study was hierarchical. Mating events for example were clustered within lactations; lactations were clustered within cows, cows within herds and herds were clustered within the client bases of regional veterinary practices. Analyses could potentially be conducted at each level. As allocation to treatment occurred at herd-level, variation in herd-level variables was considered the most likely outcome of treatment. Consequently a herd-level analysis was undertaken to correctly attribute changes in reproductive performance over time to participation in the InCalf programme.

Herd-level RCTs are rarely undertaken chiefly due to cost, logistics and the risk of failure (Dohoo *et al.*, 2010 p.214). A large number of herds are required to detect small effects of particpation in extension, requiring significant cost and logistical support, especially in seasonal systems where specific events have to occurr in all herds within very tight timelines. Alternative study designs, such as observational case studies, would not have allowed attribution of the causal effect of participation in treatment.

In preparing Chapters 3 and 4, several statistical approaches to analysis were considered. A number of lactation-level models (accounting for clustering within herd and region) and herd level models (that considered the outcome as either continuous or as a proportion) were evaluated alongside one another with the same biophysical and socio-demographic covariates. Inference of the lactation-level models were found to be similar to the herd level equivalents, so to maintain continuity between chapters the more parsimonious herd-level models were presented.

6.2.2. *Potential for bias*

The findings from this study were intended to be inferred at a national level in order to guide policy decisions on support and development of the InCalf programme. Therefore it was important that both the internal and external validity of the study design were robust. A number of opportunities for potential bias in the findings are discussed below.

Selection bias results in a systematic difference between observed and true values that occurs (over and above chance variation) when a sample population is not representative of the study population (Dohoo *et al.*, 2010 p.244).

6.2.3. *Region selection bias*

The choice of regions in this study was purposive and therefore inherently biased with regard to selection. Results of the study necessarily had to be accepted by rural professionals nationally and so needed to represent a diversity of regions. Despite 76% of herds (and 64.2% of dairy cows) being distributed in the North Island (Anonymous, 2011), two South Island regions were selected in order to fulfil this objective. There is a continuing growth in dairy cow numbers in the South Island and hence potential over representation should improve the long term validity of the inferences. Regional eligibility was also governed by the presence of a suitable and willing coordinating veterinary practice. Regional level selection bias would be reduced by sampling from a greater number of regions; however, the cost and complexity of providing regional estimates rather than an accurate national estimate would have greatly outweighed the benefit of minimising the bias at this level. Study objectives were to provide national rather than regional level measures of reproductive performance.

6.2.4. *Herd selection bias*

Participating herds were subject to some selection biases and this should be considered when interpreting these results. Eligibility criteria for herds were imposed to try to increase herd retention in the study. The criteria are discussed in more detail in chapter 2. With such a large commitment from farms in terms of on farm monitoring, these criteria were imperative. The herd selection bias could occur at two levels, through KDMs selecting to be clients of the regional coordinating practices and then client selection amongst the practice client bases. The bias from selection within regional practice client bases however, was considered minimal as only four herds were known to be actively excluded from the practices’ client base.

6.2.5. *Other study bias*

The effect of on-farm monitoring conducted as part of the study was hypothesised to increase control group awareness of the critical management factors and potentially reduce the estimated size of treatment on reproductive performance. To evaluate this potential effect, a second, passively-monitored control group was also allocated. This group effectively served to address the so-called ‘Hawthorne effect’ in the analysis (Holden, 2001). No difference was found between the two control groups suggesting that the on-farm monitoring did not artificially raise reproductive performance in the actively control group (Figure 4.6). This suggests that the active monitoring did not bias the outcome and hence the beneficial effect of treatment was due to participation in the programme and not to an increased on-farm presence of the study team. Use of a second control group has not been commonly employed in the evaluation of extension programmes.

A particular challenge for this study design was the potential for a dilution of effect of treatment through information sharing between treatment and both control group farmers and from outside sources. The regional InCalf Farmer Action Groups in this study started in 2009 following enrolment and allocation. DairyNZ launched a national campaign to promote awareness of the programme in 2008. Ideally, the study would have occurred before this promotion campaign. The effect of this campaign is unquantifiable in this study but means most importantly, that the inference of the effect of the extension was through participation in the Farmer Action Group specifically and not InCalf in general. However, the veterinary practices within which the study was run agreed not to promote InCalf during the first year of the study and specifically they agreed not to target the control herds for any additional reproductive management input. It is possible the national campaign raised awareness in the both control groups, thereby reducing the size of the difference identified between groups implying that the effect of treatment may in fact be greater than that detected.

6.3. Overview of structure and purpose of individual studies

The large amount of data collected in the current study would have allowed many hypotheses to be tested. The decision to undertake the four analytical chapters of this thesis was based on several criteria.

Firstly, the chapters provide a logical addition to the current understanding of dairy herd fertility in New Zealand. Figure 6.1 presents a proposed pathway used throughout this thesis as the path to affecting reproductive performance. The pathway reflects the upper three levels of the Bennett's hierarchy for evaluating extension discussed in Chapter 1 (Figure 1.5). Chapters 2 and 3 describe current farmer attitudes and the reproductive performance of their herds, Chapter 4 quantifies the effect of the InCalf Farmer Action Group programme on reproductive performance and Chapter 5 explores how the programme affected known risk factors for reproductive performance (Figure 6.1). This pathway provides a framework for the remainder of this discussion and to identify areas of new and productive research.

Secondly, a study of dairy herd reproduction fits well into the philosophical definition of 'systems thinking'. This philosophy attempts to understand how each factor operates in relation to the whole process of herd reproductive performance (Jackson, 2009, 2010). A complex system such as dairy herd reproduction is suited to this approach. Systems thinking philosophy proposes that through combinations of fairly simple interactions, trends arise ('multiplicity'; Strauss, 2002). Herd level management decisions inherently affect a large number of cow and lactation level interactions which should not be considered individually. An alternative analytical approach would be path analysis (Kline, 2010 p.7) where lactation level factors occurring in time are correlated to each other sequentially. For example, advising farmers on heat detection would affect a cow's time to first oestrus, that would next affect time to first service and this would impact on 6 week in-calf rate. We did not use this approach because the advice provided through InCalf Farmer Action Groups targeted multiple intervention points, e.g. transition cow feeding, monitoring pre-mating body condition, heat detection, and heifer live weight.

Thirdly, the choice reflected the objectives of the funders which included national benchmarking and assessment of InCalf; these objectives are largely fulfilled within these chapters.

It may also be necessary to reiterate what this thesis did not intend to address. There is an extensive literature of descriptive cow-level reproductive data and on associations between various animal level factors and reproductive outcomes (Macmillan, 1979, 2002b; Walsh *et al.*, 2011); hence, this thesis does not explore putative risk factors for reproductive performance. Such analysis would still be valuable and is included in the section on proposed future work.

The following sections in this general discussion chapter address each of the central steps of the pathway proposed in figure 6.1; the end result (6 week in-calf rate), the management factors that are assumed to affect the end result and the current attitudes of farmers towards a number of these management factors.

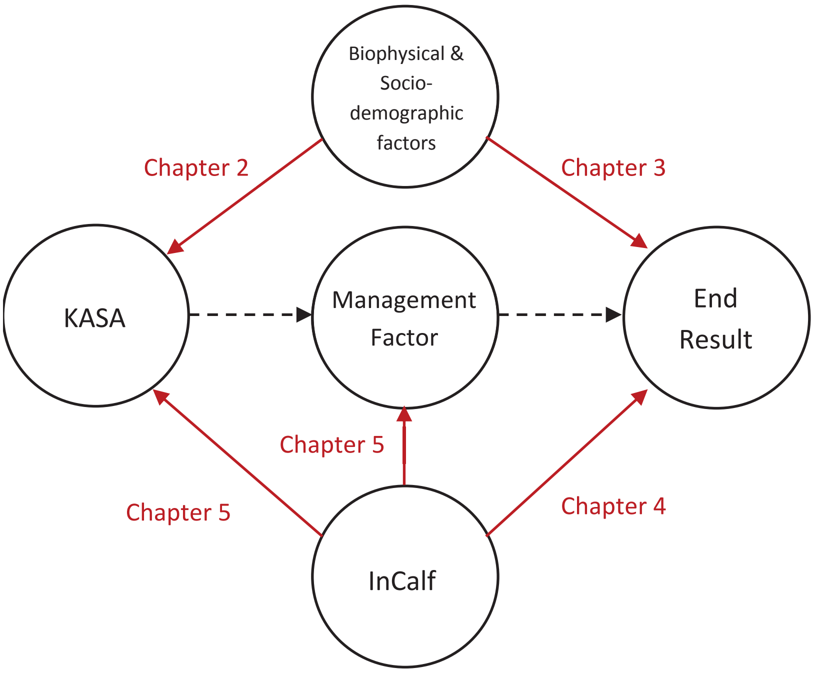

Figure 6.1. Simplified schematic of the proposed pathway to effecting change in reproductive performance and chapters presented in this thesis (red). The end result in this case is reproductive performance measured as 6 week in-calf rate, and changes in key management factors that may change the end result and the changes in KASA (Knowledge, Attitude, Skills and/or Aspirations) that are proposed in order to change management practice. Biophysical and socio-demographic factors include farmer, farm and herd factors that potentially interact with this pathway and InCalf represents the agricultural extension programme evaluated in this thesis. Key management factors considered included calving pattern, heifer live weight, precalving and premating body condition score, oestrus detection, anoestrus cow management, bull management.

6.4. The end result of the effect of the InCalf Farmer Action Group: the 6 week in-calf rate

When using the Bennett's hierarchy for evaluating the outcomes of an extension programmes (Figure 1.7), the end result measure is the gold-standard for evaluating the effect (Bennett, 1975). A clear definition of the end-result criterion is satisfied in the current study which assessed an improvement in 6 week in-calf rate attributable to treatment. In this case a statistically significant improvement was suggestive of a successful effect of the Farmer Action Group.

In order to first establish a baseline measure of current 6 week in-calf rate, the accurate conception data from pregnancy diagnosis of control group only over the 2009/10 and 2010/11 study-years were analysed and reported in Chapter 3. The hypothesised effect of treatment on reproductive performance made inclusion of the treatment group herds inappropriate in this analysis. Chapter 3 accompanied Chapter 2 and fulfils the descriptive objective of the overall study. Chapter 4 evaluated the primary objective of the overall study; to quantify the effect of participation of dairy farmers in an extension programme on the 6 week in-calf rate using a RCT incorporating the treatment herds.

When comparing the results of Chapter 3 to the previous benchmarking study undertaken in 2000 (Xu and Burton, 2003), it appears that the national average 6 week in-calf rate is no longer in decline, although some caution is required when comparing the two different studies with different study populations and methodologies. Submission rate has remained similar also but conception to first service may have fallen. Therefore, in order to maintain a similar 6 week in-calf rate, a higher second 3 week submission rate (22 – 42 days post MSD) must occur. This raises a question over the role of the 6 week in-calf rate as the ideal sensitive measure of reproductive performance. If it is used as the sole measure for reproductive performance, changes in 3 or 6 week submission rates and likewise a reciprocal change in first service conception rate would be undetected. It was retained as the principle outcome measure in these analyses as it remains regarded by the industry as the principle measure of reproductive performance however inclusion of 3 week in-calf rate could increase the sensitivity of the national and regional reporting. For example, effective use of anoestrus treatments has been found to alter the interval from MSD to conception, especially in cows in anoestrus, yet with little impact on 6 week in-calf rate. It is likely that increased use of hormonal treatment would reduce conception rate but increase submission rate of a herd, especially resubmissions in the second 3 weeks (McDougall 2010a). This management change would be unlikely to significantly affect the 6 week in-calf rate.

A 2% difference in 6 week in-calf rate was detected during the year of treatment. The difference remained in the second year but did not increase suggesting that the improvement was sustained but didn’t compound in the subsequent year. Evidence of a transitory improvement in performance following involvement in an extension program has been found in the USA (Peters *et al.*, 1994a). The improvement in herd performance detected in that study decreased to normal after two years suggesting that a sustained improvement might require on-going extension support. Anecdotal evidence from participants of this study was that a continuing increase was observed in the year after the study (2011/12). Analysis of further year’s reproductive performance is strongly suggested to monitor the longer term effect and is proposed in the section on future work. If the difference remains or increases, a strong case would be evident for continued support and development of this programme. Should it decrease and return to baseline, then the findings would support an industry decision to either abandon or substantially redevelop the InCalf Farmer Action Group programme. A reduction in the difference in performance in the 2011/12 years, would suggest that the current Farmer Action Group extension model is not sufficient to maintain the improvement needed to achieve the national target of average 78% 6 week in-calf rate. Restricting exposure to the InCalf Farmer Action Group from the control group beyond the duration of the study could not be mandated however.

Biophysical and socio-demographic associations and interactions with end result

Random allocation precluded the need to include the biophysical and socio-demographic variables in the model evaluating the effect of treatment to account for potential confounding (Austin *et al.*, 2010). Where potential interactions between treatment group and each variable were tested no significant interactions were identified, although a trend towards an interaction between treatment group and preceding years performance was observed, and this is discussed below. Season and region were included in the model as fixed effects due to the study design. Regional differences in treatment were hypothesised for a number of reasons:

1. Different levels of follow-up delivered by the coordinating veterinarians and practices between regions. This study intended to evaluate the effect of being involved in the InCalf Farmer Action Group, hypothesised to be the most effective way to deliver the (plan-do-review) process of InCalf. However, the InCalf programme facilitates opportunities for farmer-advisor interaction outside of the meetings. Depending on the level of adoption of InCalf by the veterinarian and/or practice, variation might be expected in the degree of that support.

2. Expertise in facilitation during the meetings. The process of facilitation is not the same as the technical role of the veterinarian in practice and regional veterinarians only received a single day of formal training in facilitation. Anecdotal evidence was that this was insufficient to develop facilitation skills. Furthermore, continued support and coaching of rural advisors is not currently provided by the InCalf programme. Where the role of good facilitation was not well undertaken during meetings, farmer disengagement was a possibility.

Analyses in Chapter 3 found the preceding year's performance was the strongest predictor of current performance. This would appear logical as the same KDM was managing the same herd in both years of the study. An alternative interpretation suggests that a small change in reproductive performance between years was more likely than a large change and that this slow incremental change could potentially be long term. A longer study period would be required to follow this trend and is recommended in the further work section. This finding is in agreement with Vanclay's principles of extension, discussed in Chapter 1, which state that change as a result of participation in extension is likely to be small (Vanclay, 2004). This should form an important message for extension providers that improvement should not be overestimated or 'over-sold'. The value proposition for KDMs to participate in extension should be constructed around small but incremental gain rather than an unachievable target. Furthermore, a trend was identified between the effect of treatment and quartile of preceding reproductive performance whereby the lowest performing quartile of herds had the largest response to participation. Although logically these herds had the greatest potential for improvement, a 5% greater improvement was seen in the treatment herds when compared to the control herds. This would suggest that extension would be most effectively targeted at the lowest performing herds in order to achieve the greatest effect.

As shown in Chapter 3, other biophysical and socio-demographic factors evaluated did not account for much variation in 6 week in-calf rate. This challenges an anecdotal belief that factors such as large herd size are predictive of poorer reproductive performance. Large herd sizes require a greater number of staff and a greater potential for diminished responsibility for performance amongst staff undertaking most of the day to day duties. This has been used to justify poor performance in large herds. The findings from this study suggest that large herd size should not be used as a general excuse for poor performance since the distribution of performance is equal across herd sizes.

6.5. Management factors

In order to improve the end result, the 6 week in-calf rate, it is proposed that one or management factors needs to change (Figure 6.1). Chapter 5 examined the effect of the InCalf Farmer Action Group on the six of the eight management factors included in the current InCalf extension programme as the important determinants of reproductive performance (calving pattern, heifer live weight, precalving and premating body condition score, oestrus detection, anoestrus management and bull management).

The original aims of Chapter 5 included 1, describe and compare the six management factors for each treatment group, 2, quantify the effect of the InCalf programme on the self-reported management changes for the key management factors using periodic interview data, 3, describe the intended actions proposed during the prepare sessions, and 4, quantify the effect of these intended actions on the key management factors. Together, these aims were found to be too ambitious, so the following approach was used to evaluate the InCalf process:

1. Compare herd performance between treatment and control groups for the six management factors that affect reproductive performance in the year of the treatment, and/or the subsequent year;

2. Describe the proportions of farmers participating in an InCalf Farmer Action Group that intended to change management associated with each key management factor; and

3. Describe the association of intending to enact these changes with the key management factor in comparison with those farmers not intending any changes.

Due to the seasonal dairy cycle and the periodic exposure over the year, the temporality of exposure had to be considered. Vickers (2001) established that that the highest statistical power in randomised controlled studies was attributed to using analysis of covariance (ANCOVA) of post exposure measurements and including the pre-exposure status as a covariate. Accordingly, only post exposure measures were evaluated in this analysis and pre-exposure measures were included as fixed effects where appropriate. Where the first study-year measures were undertaken before any realistic likelihood of the effect of InCalf was anticipated (for example, precalving BCS measured in the same month as the precalving planning session in the first year of the study), only the second study-year measures were evaluated. Where the technical area was addressed in the farmer action group in advance of the measure and could be assumed to be reasonably effective (for example, premating BCS), the measures were pooled across the two years of the study. This method, while the most acceptable, results in two-years of data (and hence more power) for some measures and not to others.

The outcome of these analyses found improvements in three of the six risk factors analysed (heifer live weight, precalving and premating BCS and oestrus detection; $p<0.05$). Conversely, no difference was observed in calving pattern, anoestrus and bull management factors between groups ($p>0.05$).

The measures used to appraise both anoestrus cow management and bull management were novel and have not been used in previously published studies. Currently there is a need to establish a biologically meaningful industry-wide agreed measure for these two management factors. For example, a higher or lower proportion of the herd treated for anoestrus is not necessarily indication of improved or declining management, whereas the treatment preceding MSD is suggested as best practice (McDougall, 2010a). In fact, the dairy industry strategy advocates minimal hormonal intervention. While this is a worthy longer term goal, reducing hormonal use in the short term may result in slower improvement and hence delay cessation of hormonal use from a farm.

The second and third objectives of this chapter sought to quantify the effect of the intention to improve management stimulated by the Farmer Action Group. As outlined in Chapter 1, intention is assumed to be a critical step between a change in attitude and change in practice. Bigras-Poulin *et al.* (1985b) identified that the intention to undertake a practice change was not consistent amongst farmers and could be enacted with different levels of conviction. I believe this is evident within our study results, where the actions proposed by farmers during the course of the Farmer Action Group meetings were considered as intentions to change. These intentions were recorded within groups of two or three, and made up of farmers likely with different beliefs, attitudes and social norms. It is likely that some intentions were proposed through obsequiousness or perceived obligation to other farmers or the facilitators. This perhaps also contributed to the poor adherence to the S.M.A.R.T. principles also promoted by the programme (Doran, 1981). The results from Objective 1 imply that the InCalf Farmer Action Group had a measurable positive effect on submission rate, BCS and heifer weights, but this was not achieved through the process of proposing written actions during the sessions. In fact, herds that proposed the greatest numbers of actions (six to ten proposed actions) achieved lower average 6 week in-calf rates in the second study-year than herds that had proposed five or fewer actions (Figure 5.4). Current extension theory, discussed in Chapter 1, holds that building the capacity of participants to make necessary changes is most effective. Proposing actions in this format adheres to this theory; however, I believe that this paradox suggests that the process of writing down proposed actions in the buddy group format is inefficient rather than ineffective. Evidentially, participation in the InCalf successfully improves three of the six factors but the mechanism was not apparently via writing down proposed actions. A more efficient method of deriving effective S.M.A.R.T. plans needs to be developed.

Within systems thinking philosophy, it is feasible to correctly reject a null hypothesis but for incorrect reasons (a type III error; Kaiser, 1960). Without this study, a type III error might have resulted, with the overall effect of the InCalf Farmer Action Group being attributed to the action of proposing management changes during the sessions. Further work is clearly needed to understand how the effect of the InCalf Farmer Action Group brought about the change in reproductive performance. This is proposed in the future work section.

6.6. Knowledge, Attitude, Skills and/or Aspirations

The aim of Chapter 2 was to examine baseline attitudes, priorities, and constraints pertaining to herd reproductive management perceived by farmers in the study, and to explore how these varied with socio-demographic and biophysical factors. The broader aim was to identify predictors of attitudes about reproductive performance. Where predictors of particular attitudes, such as satisfaction with reproductive performance, are associated with biophysical or socio-demographic factor such as farmer age, extension messages can be targeted more specifically. This is potentially important when designing and implementing extension programmes to influence the behaviour of farmers.

This was the first published attempt to formally characterise the attitudes of dairy farmers in New Zealand; consequently, there are no comparative studies. Other attitudinal studies conducted in dairy industries abroad focussed on differing aspects of farmer attitudes, so direct comparison of results is inappropriate (Garforth *et al.*, 2006; Jansen *et al.*, 2009; Kuiper *et al.*, 2005; Rehman *et al.*, 2007).

In the early study design, the social science questionnaire was expected to be an additional component to run alongside the main biophysical study. However, as the study progressed, it began to take a more central position in my understanding of the process behind adoption of practice change. Consequently, the scope of the annual social science questionnaire was augmented and a greater range of data were collected in subsequent years including a series of questions concerning attitudes, beliefs, social norms and perceived control based on the theory of planned behaviour (Ajzen, 1991a). While examining the data from those interviews was outside the scope of this thesis; it is hoped that future analysis of that data will explore the hypothesis that the intention to change management factors to improve reproductive performance is effected by participation in the InCalf programme.

The questionnaires principally captured quantitative responses from participants. Evident in these quantitative responses was that with increased specificity of questioning, there was greater diversity of response between farmers. For example, where farmers were asked to rate their self-motivation for their job, the majority rated this highly with little variation between KDMs whereas rating specific perceived constraints on their herd reproductive performance had greater variation between KDMs. Ideally, the questionnaires would have captured qualitative answers allowing for greater personal expression and greater specificity from each farmer. Predominantly qualitative interviews were beyond the experience and budget of the study team as they require specialist interview technique and even greater experience to fully interpret the results. Ultimately, a quantitative style was appropriate as the interviews were conducted by veterinary technicians with only rudimentary interview training. The majority of questions were closed-ended (i.e. finite options were given) and most responses were recorded on Likert type scales (1 to 5 where 1 might be very unhappy and 5 might be very happy) which improved the reproducibility of the questions within technician as well as between technicians.

The results highlighted a potential barrier to herd-improvement in that the majority of farmers indicated that they were satisfied with the reproductive performance of their herd. When considered alongside the decline in national average performance over the last 20 years (Harris, 2005), this suggests a disconnection between farmer perception of satisfactory performance and the industry target for performance. This represents a real barrier to the dairy industry achieving targets. A belief exists that there needs to be a ‘tension for change’; that a perception by the decision maker that something is required to change, before any actual change will occur. Currently, national and regional benchmarking of reproductive performance is not available in New Zealand. Promotion of reproductive benchmarks and targets should create tension in some farmers. Although no regional difference was detected in this study, anecdotal evidence would suggest that regional benchmarking would be necessary to account for farmer belief of regional differences.

A second finding that reflects anecdotal experience was the perception of farmers that the non-cycling (including true anoestrus cows) proportion of the herd during mating was the biggest constraint on reproductive performance and oestrus detection had a lower impact. Whereas the non-cycling proportion might be perceived by farmers as inherent in the phenotype of the modern dairy cow and thereby outside their control, oestrus detection is fundamentally a reflection of farmer expertise. To rank oestrus detection as a constraint would be a self-criticism of a farmer’s ability and where oestrus detection is poor, cows not detected in oestrus would be considered in anoestrus. However, this is over-simplistic and both the rate of anoestrus cows and submission rate are interdependent. Despite these rankings, the findings in Chapter 5 indicate that the submission rate of mature early calved cows was improved significantly as a result of participation in InCalf. However, despite ranking anoestrus cows as the highest perceived constraint, farmers participating in the Farmer Action Group adopted a less effective approach to anoestrus interventions. This paradox might be explained in two ways: firstly, good oestrus detection practices were positively encouraged during the Farmer Action Group and the immediate benefits of these practices could be measured by an increased submission rate in the first study-year and secondly, the Farmer Action Group facilitated prioritising management factors. Potentially, non-cycling cows might not have been proposed as a high priority and this secondary importance to other management factors may explain the less timely intervention regime. An anecdotal effect of the Farmer Action Group was farmers focussing on the management factors with the greatest gaps in performance, sometimes to the detriment of other factors.

This disconnection between farmer attitude and management practice change is an area for development within the InCalf programme. A British study on adoption of heat detection methods, discussed in Chapter 1, identified ‘not acknowledging farmer expertise’ as a barrier to uptake of novel oestrus detection technology (Garforth *et al.*, 2006). It is reasonable to assume that this opinion would also be valid in New Zealand. Strategies to improve submission rates should not circumvent farmer expertise as the conclusions of the British study suggest this would be a barrier to adoption.

The study also identified biophysical and socio-demographic variables associated with attitudes, priorities and perceived constraints. These chosen variables are commonly used as factors used to differentiate dairy farmers and their farming operation (for example, farmer age or the predominant breed of the herd). Most extension developers and rural professionals (including veterinarians) would have an understanding of these same descriptive variables for their clients.

A targeted development of extension for different farmer age categories was recommended due to the greater proportion of the variability in attitude being explained by age category than other factors. This recommendation was based on the assumption that certain attitudes (such as satisfaction with reproductive performance) correlate with reproductive performance. In Chapter 4, the same biophysical and socio-demographic factors did not predict reproductive performance however. This paradox suggests that biophysical and socio-demographic variables are unlikely to exert a confounding effect on any association between farmer attitude and reproductive performance. There is a need to further examine this relationship. If a significant association exists between one or more attitudes and reproductive performance, a greater advantage would be found if the intermediate step(s) (management factor(s)) were also identified.

The research in the current study does not create a complete picture of farmer attitudes and beliefs, but provides a starting point for further research. Future questionnaires might increase focus on farm staffing matters and external factors, such as the weather. It was felt that these were not addressed in sufficient detail by the current questionnaires.

6.7. Critical implications of study findings for further extension activities

Reproductive performance must remain a focus for the New Zealand dairy Industry if it is to remain competitive in the future. The 6 week in-calf rate appears not to have declined over the last decade but conversely, no gains have been made toward the Industry target of a national average 6 week in-calf rate of 78% by 2016.

The following questions and statements identify and discuss critical elements for future InCalf activities:

6.7.1. *General farmer satisfaction with reproductive performance is a barrier to achieving practice change.*

Farmer satisfaction with reproductive performance is likely to be a barrier for improvement. Marketing principles suggest that shifting a *status quo* requires a consistent and enduring message (Vakratsas and Ambler, 1999). Exposure to consistent national and regional targets from multiple sources (rural professionals, decision support systems, education bodies and printed press) is necessary. It is also imperative that the rural professionals providing this advice also believe and endorse these targets. Robust and accessible evidence should be available to all industry sectors. Inclusion of national and regional mean and quartile measures of reproductive performance (e.g. 6 week in-calf rate) in the National Dairy statistics would provide a suitable benchmarking tool.

Furthermore, realistic expectations are needed among industry stakeholders of the length of time needed for social change in attitudes and beliefs to occur.

6.7.2. *Previous performance is the biggest predictor of reproductive performance.*

As previous performance most probably predicts current performance, improvements (or conversely declines) in reproductive performance are likely to be small and slow. This is an important message to convey to farmers and extension providers engaging in extension to ensure that expectations of participation are well managed.

6.7.3. *Many biophysical and socio-demographic factors are not associated with reproductive performance (e.g. region or herd-size).*

Previous dogma surrounding a poorer reproductive performance in large herds is fortunately unfounded according to the results of this study. This implies that a need for extension exists in all regions, across all herd sizes, farmer age categories and owner-ship structure and that this advice does not need to be tailored to farmer age groups or herd sizes. Better performance was found in predominantly extensive farming systems when compared to intensive systems in most regions.

Extension should be able to facilitate different management practice decisions according to these broad production types.

6.7.4. *On average, a 2% improvement can be attributed to the effect of participation in the InCalf Farmer Action Group.*

At the outset of this study the Farmer Action Group extension model was hypothesised to be the most effective extension model and was chosen as the treatment method employed in this study. A 2% overall improvement in 6 week in-calf rate was achieved during the two years of the study with the greatest improvement occurring during the first year. The on-going efficacy of the extension is not yet known.

The dairy industry must now decide if this is a sufficient improvement in order to continue funding the Farmer Action Group model. If the industry target (of 78% national average 6 week in-calf rate by 2016) is to be achieved within four years use of the InCalf Farmer Action Group alone (despite its proven benefit) will not be sufficient. It is not clear from the current study whether the technical content of InCalf is complete (i.e. are there potential risk factors omitted as discussed above?) or whether the Famer Action Group model assessed in the current study is effective for different reasons to those hypothesised. Improvements or alternatives to InCalf generally, to the Farmer Action Group model and/or to facilitator training are required.

6.7.5. *The greatest improvement is seen in lower performing herds.*

Although not statistically significant at this sample size, a numerical trend suggests that focusing extension on the poorest performing herds would provide the greatest improvement in performance. This challenges a second dogma that the poorest performing herds are also non-participatory and less likely to adopt practice change. An average 5% greater improvement in 6 week in-calf rate was attributed to participation in the Farmer Action Group in the lowest performing quartile of herds when compared to the control group. A national focus by rural professionals on the lowest quartile of herds for extension would improve national reproductive performance faster. Accessible farm-level benchmarking would need to be made available to RPs in order to use this strategy.

6.7.6. *The InCalf Farmer Action Group improved three management factors affecting reproductive performance*

The InCalf Farmer Action Group may have exerted some of its effect through significant improvements in three of six key management factors studied in the year after treatment: Heifer live weight, cow body condition and oestrus detection. While this is encouraging, improvements to the

InCalf programme should address the remaining three risk factors examined: Improving calving pattern, management of anoestrous cows and management of bulls.

6.7.7. *Measures for some management factors are imperfect*

No direct measure of anoestrus, bull management or in fact, oestrus detection were available in this study. The study chose novel proxy measures for these factors and recognises the limitations in the specificity of each measure. Further work and agreement within the industry is needed to improve these measures if monitoring and benchmarking are to occur. Milk progesterone testing and/or pre mating heat recording can provide accurate measures of postpartum anoestrus and heat detection, however, there use at a national level requires a huge increase in record keeping within each herd. This is unlikely to happen with current technology.

6.7.8. *Are the correct management factors being targeted?*

These risk factors were identified in Australia more than 10 year ago (Morton, 2004) and have been accepted as the key components for reproductive performance by the New Zealand InCalf programme. While there is a generous body of evidence that supports each of these as risk factors for performance, little work has been undertaken to confirm all putative risk factors in New Zealand. Several additional potential risk factors and their contribution to reproductive performance need to be evaluated. The current dataset provides an ideal framework to investigate and partition the risk between some additional risk factors.

A potential component could be the genetic selection for production that has predominated breed selection over the past 100 years. The Australian study was undertaken approximately 15 years ago and genetic technology since then has advanced. The association of genetic selection for milk solid production and reduced fertility has received considerable attention (Baudracco *et al.*, 2011; Lucy, 2001; Lucy *et al.*, 2009; Macdonald *et al.*, 2008). A key finding is the association between this selection for production, especially the introduction of North American and European genotypes, and lower reproductive performance. This has been recognised chiefly in lower conception rates and higher proportion of cows not detected in oestrus before mating in New Zealand herds. If this risk factor is a significant contributor to reproductive decline, the InCalf programme needs to recognise genetic selection with much greater emphasis on bull selection for reproductive performance.

Animal health was not identified as a key risk factor for low 6 week in-calf rate in the Australian study and was added as an additional component to offset resistance of veterinarians toward an extension programme that didn’t incorporate animal health. The topic does not address endemic infectious disease other than suggesting that veterinary intervention may be sought. We know that some diseases can have profound effects on reproduction, e.g. BVDV, IBR and Leptospirosis (Brownlie, 1990; Dhaliwal *et al.*, 1996; Yates, 1982) and that some of these are prevalent in New Zealand herds (Heuer *et al.*, 2007; Hill *et al.*, 2010). It is evident that their control, and even eradication, could have a significant impact of reproductive performance. The National Herd Fertility Study shared its sample population with a BVDV study running concurrently in New Zealand. A full analysis of these results with regard to the impact on reproductive performance could identify BVDV as a risk factor separate to other endemic disease. BVD control requires a comprehensive understanding of the complex aetiology and epidemiology of the disease. InCalf would provide an ideal platform for the dissemination of better decision making around its control.

Uterine health has become a focus of research in recent years (McDougall, 2001a). Retained fetal membranes (RFM), metritis, and endometritis have been shown to have a negative effect on reproductive performance (Heuer *et al.* 1999; McDougall 2001b). Lactation level data were collected on recorded cases of endometritis and metritis. It was likely collected inconsistently between herds, so within herd analysis could be undertaken to evaluate the effect of recognised and recorded events.

6.7.9. *The improvement in reproductive performance identified in this study must be attributed to a Farmer Action Group model and not to InCalf alone.*

An alternative extension model incorporated in the InCalf extension programme is the one-on-one consultation model. This method was originally hypothesised to be less effective than the Farmer Action Group and was not evaluated by this study. If stakeholders decide that the modest returns on investment in the Farmer Action Group model are insufficient, the one-on-one consultancy model should be evaluated. A full evaluation of the effect of a one-on-one would require a similar size and scale study to this National Herd Fertility Study.

The one-on-one model aligns more closely with the normal veterinary consultation and does not require group facilitation skills (although, the process of decision making should still be undertaken by the farmer to be effective). This may be a more attractive option to veterinarians uncomfortable and unfamiliar with facilitation. Although not evaluated in this thesis, anecdotal reports from participating veterinarians were that the training for facilitation as part of InCalf training was insufficient and no formal on-going support was offered. Post study interviews were undertaken with the regional veterinarians by Dr Ian Tarbotton and the findings will be included in the future development of the InCalf extension programme. No significant regional interactions were identified in the multivariate model quantifying the effect of treatment on reproductive performance. Region was included *a priori* due to the hypothesised regional difference in the provision of the Farmer

Action Group and support outside of the meetings. This suggests that the Farmer Action Groups were undertaken and supported evenly between regions.

6.7.10. *InCalf Farmer Action Group action plans undertaken in small group are not associated with behavioural change and are therefore inefficient*

The majority of actions proposed during the Farmer Action Group did not fulfil the smart, measureable, achievable, reasonable and time bound (S.M.A.R.T.) criteria (Doran, 1981). This was most likely due to lack of appreciation or understanding by both the farmers and facilitators of the impact of S.M.A.R.T. plans. The proposed actions were not associated with change in management behaviour following the Farmer Action Group. Shared anecdotal experience amongst facilitators of the Farmer Action Groups suggested that many actions were proposed with some obsequiousness and without the full intention to comply. This finding suggests that the process of proposing S.M.A.R.T. actions within small farmer groups of two to three is inefficient. The inefficiency could be due in part to poor understanding by farmers of the effectiveness of S.M.A.R.T. actions, the lack of time allowed to undertake this planning or a need for improved facilitation training among the extension providers. In this study, experienced facilitators from outside each region attended each session. However, current facilitation training for InCalf advisors undertaking the facilitator training comprises of a single or two day course. It is likely that this is insufficient to help extension providers accumulate to the skills of facilitation. Further discussion is needed regarding facilitator training and on-going support.

6.7.11. *Voluntary farmer participation in a commercial Farmer Action Group model was not evaluated.*

The InCalf Farmer Action Group was tested under conditions of farmer allocation to the group by the research study. Criteria to test likelihood of voluntary farmer participation in a commercial Farmer Action Group could not be evaluated because the random allocation did not allow farmers to self-select to participate in the extension group. Farmers were invited to participate in the National Herd Fertility Study instead, with the understanding that random allocation would allot them to a Farmer Action Group or a control group. Hence it is possible that farmers independent to the study that elect to be involved in commercial farmer action groups may have a higher level of commitment to change and hence find a greater improvement in 6 week in-calf rates.

To drive participation and adoption in the InCalf programme, rural professionals need to be able to provide a value proposition to potential farmers. Justifying the cost of participation needs to be addressed in this value proposition. The cost of the InCalf Farmer Action Group is likely to present a barrier to participation in an industry that has not grown into a culture of paying for extension and one where much information is freely available. Participants allocated to the Farmer Action Group in this study had the fee substantially subsidised. To be viable for advisors, the Farmer Action Group would likely cost an individual farmer attendee approximately $2,000. Using the national average herd size of 386 cows (Anonymous, 2011), the average 2% increase in 6 week in-calf rate and the $4 estimated profit/loss of a percentage change in 6 week in-calf rate (Beukes *et al.*, 2010) a $3,088 profit during the year of participation can be realised. This adequately offsets the cost of participation, and alongside the additional expected profit as a result of reduced final not-in-calf rate, would make participation profitable. This simple benefit cost analysis would help rural professionals promote and justify participation in a Farmer Action Group.

Another strong driver for uptake of agricultural extension is the commitment and enthusiasm of the rural professional providing the service. In this case, it was predominantly the regional veterinarian.

6.8. Future work

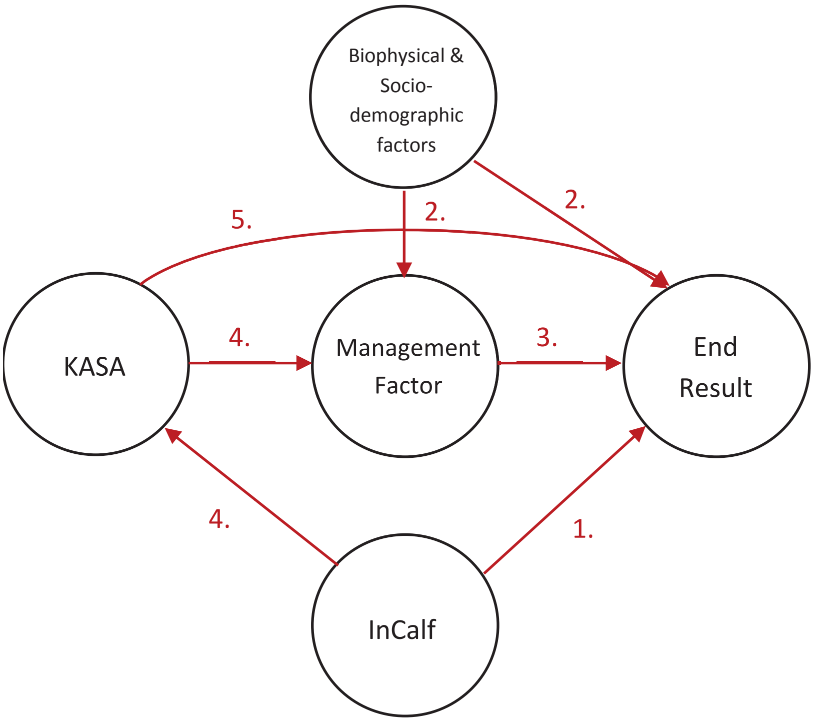

Figure 6.2. Simplified schematic of the proposed pathway to effecting change in reproductive performance and proposed future work (red) of the National Herd Fertility Study. Numbered pathways are discussed in the text. The end result in this case, is reproductive performance measured on 6 week in-calf rate, and changes in key management factors are proposed in order to change the end result and change in KASA (Knowledge, Attitude, Skills and/or Aspirations) are proposed in order to change management practice. Farm factors include farmer, farm and herd factors that potentially interact with this pathway and InCalf represents the agricultural extension programme evaluated in this thesis.

The studies presented in this thesis do not provide all of the information needed to enhance the effectiveness of the InCalf programme. Further areas for research using this dataset are illustrated in Figure 6.2 by applying the same schematic used to propose the pathway through which InCalf effects change. These suggested areas, and others are outlined below, each point relating to numbers in Figure 6.2:

1. A further analysis of the third year of the study is required to assess the longer term effect of participation in the InCalf Farmer Action Group. Although active on-farm monitoring has not been undertaken, data from the National Dairy Database for the 3rd year (i.e. 2011/12) after study initiation has been downloaded and awaits analysis. Without the mandated pregnancy diagnoses, an estimate of the 6 week in-calf rate derived using the Fertility Focus Report algorithm would be analysed.

2. The effect of biophysical factors (such as cow phenotype and disease events) on reproductive performance can be analysed using data from this study. Several published studies have evaluated specific risk factors at lactation-level (McMillan 2002, McDougall 2001a). In addition, this dataset offers an opportunity to explore multi-level factors, by accounting for herd-level factors. The relative contributions of each cluster level (cow, herd or region) can be quantified by partitioning the variance between each level. This would inform resource allocation to further research a particular level, whether cow or herd.
3. As discussed earlier, a cross-sectional study of New Zealand dairy herds identifying herd-and cow-level risk factors for reproductive performance has not been undertaken, and current key management factors used by the New Zealand InCalf programme have been accepted from Australian Dairy Herd Fertility Project based on work now 15 years old. Putative risk factors might include genotype, BVD and other recorded disease events. Further analysis of this dataset may identify critical risk factors that are not sufficiently addressed in the InCalf programme. Furthermore, the contribution of each management factor could be evaluated to establish if a change in each factor were additive or multiplicative on other factors and reproductive performance.
4. The effect of farmer participation in an InCalf Farmer Action Group on change in attitude and management practice would provide further information on the extent of the effect of the InCalf programme (level 4 of the Bennett's hierarchy). A longitudinal analysis of questionnaire data could be undertaken on self-reported attitude and practice change that would inform extension development.
5. The longitudinal effect of farmer participation in an InCalf Farmer Action Group on change in attitude and reproductive performance would also provide further information on the extent of the effect of the InCalf programme. Using cross sectional questionnaire data employing the theory of planned behaviour, changes in attitude, perceived norms and control could highlight areas where greatest and least effect occurs helping drive focus for extension development
6. Analysis of qualitative cross sectional interviews undertaken with regional veterinarians providing the facilitation during the InCalf Farmer Action Groups and respective regional practice managers could be analysed to identify the extent of adoption of the extension programme into the practice policy and identify areas for support or improvement (not included in Figure 6.2).

6.9. Conclusion

This thesis has provided the epidemiological and social evidence to quantify the effect of farmer participation in the InCalf Farmer Action Group at a herd-level. The baseline reproductive performance and farmer attitudes provided robust data on which to base decisions about national strategy towards dairy herd reproductive performance. The results indicate that reproductive performance was similar to that of the last decade, suggesting no further decline but that high levels of farmer satisfaction with current performance was a barrier to improving this. The relationship of attitudes and performance with common biophysical and socio-demographic factors challenge established myths such as the association of large herd size with poor reproductive performance and propose others for consideration by extension strategists, for example a considerable gap exists between the industry goals and the current performance with a large resultant cost to the industry.

The national randomised controlled study demonstrates that farmer participation in an InCalf Farmer Action Group gives an average 2% improvement in reproductive performance during the year of the intervention over herds where farmers did not participate. The greatest effect was seen in the lowest performing herds and these should become the focus of future extension. Improvements made to achieving practice change for certain management factors where the InCalf Farmer Action Group has not proved effective could lift performance still and further work is needed to evaluate the extent of the effect of participation on attitude change. The industry now has a basis for deciding if it is deemed worthwhile to invest further in this model of extension and to improve it using the recommendations from this thesis.

It is evident a change in focus from the physiology of the cow to behavioural change of key decision makers can effect real change. A greater understanding than was possible to provide within this study is therefore required, for demonstrating how behavioural change can be achieved in order to make decisions that are more predictable and, more importantly, sustainable. The chain of events that leads to a good decision involves others, and in the New Zealand dairy industry, rural professionals can provide the evidence-based support for this decision. If our good work is to be of benefit, then these messengers need to be understood too.

It is likely to be a fascinating future for the New Zealand dairy industry and the farmers and rural professionals striving to improve it. If we intend to make those two blades of grass grow where only one grew before, we need everyone working together.

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*Non-peer-reviewed

Appendix 1

Confidential key decision maker base-level questionnaire

Interviewer ....

Date and time...

Supply number ……………………………………………………………………………….

Who was interviewed? ....

Who else was present? ....

Section 1

Thank you for taking the time to answer these important enrolment survey questions

The questionnaire is organised into three sections: Your opinions, your herd and some disease information

1. How many years have you been dairy farming? ....

2. To which age group do you belong? ☐ 20 – 29 ☐ 30 – 39 ☐ 40 – 49 ☐ 50 – 59 ☐ 60+

3. What made you decide on farming as a career? (Please enter more than option if appropriate)

☐ Financial ☐ lifestyle ☐ had the necessary skill set ☐ inherited farm ☐ other (please specify).........................

4. Do you have any post-school tertiary training or qualifications? ☐ Yes ☐ No

5. Have you got ultimate decision making and expenditure sign off for?

Area	Yes	No, if No who does?
Annual budget approval	If Yes, please skip the remainder of the table	If No, please continue below
Genetic sire selection		
Bull management		
Length of AI		
Heat detection		
Use of synchronization/non-cycler treatment		
Animal health		
Grazing management/purchasing feed		
Staff selection/management		

7. Could you rate each of the following out of five...
(Please consider that not all areas can be your highest priority)

		Very low				Very high
		1	2	3	4	5
Your self-motivation for your job						
Your appetite to learn more						
Your attention to detail						
Your herd's current milksolids performance						
Your herd's current reproductive performance						
Your herd's current genetic quality						
How important is it that seasonal farm tasks are performed on time						
The importance of following proven farming protocols						
Likelihood of trying new, relatively unproven ideas or technology						
Benefits to you from 'group learning' with farmers						
Your ability to manage your staff	☐ n/a					
Importance of choosing staff to match the role	☐ n/a					
Importance of staff training and improvement	☐ n/a					
The value of ideas or suggestions from your staff						
The importance of delegation						
Importance of farm-succession planning for the long term						
The importance of on-farm data monitoring						
The importance of farm vehicles, tools and machinery						
The importance of good tracks, fences, water system and pastures						
Your level of influence on other farmers						

8. In the last 3 years what are the key changes you have made to your farming operation?

1. ....

2 ....

3 ....

9. How would rate each of these areas against each other as priorities for you over the next three years?

(It may be necessary to show the interviewee the table here)	Very low				Very high
	1	2	3	4	5
Animal health					
Cow nutrition management					
Environmental sustainability on your farm					
Farm business management					
Herd genetics					
Herd milksolids performance					
Herd reproductive management					
Milk quality					
Pasture management					
Staff management ☐ n/a					

10. Do you have written farm goals? ☐ Yes (please answer the following questions) ☐ No (please go to question 12)

11. For which areas do you have written goals? (Select as many as you like):

Farm finance ☐	Reproductive management ☐	Pasture management ☐	Environmental sustainability ☐
Equity growth ☐	Herd milksolids performance ☐	Staff management ☐	Other (please specify) ☐

12. What is your main <u>measure</u> of ‘successful’ farming on your farm? ....

....

13. Where did you get your information about FARMING from in the last 3 years...

Source	Did you use this source (please circle one)	What did they advise on	Value 1 = little 5 = a lot	Name or example	Company (contact details if possible)
Farm consultant	Yes or No				
Other farmers	Yes or No				
Vets	Yes or No				
Discussion groups	Yes or No				
Accountants	Yes or No				
Dairy NZ sources/staff	Yes or No				
The internet	Yes or No				
Written media or books	Yes or No				
Other	Yes or No				
Other	Yes or No				
Other	Yes or No				

14. Who do you classify as your key advisor about herd reproduction? ....

15. In the past, have you been involved in benchmarking? ☐ Yes ☐ No (If No, please move to question 17)

16. Please list any benchmarking you are involved in: ....

....

17. How many people (including you) WORKED on the farm during the 2008/09 season?
Please exclude temporary short term staff (e.g. help over calving, relief milkers)

	How many full time staff? (please indicate how much if not full time)	How long have each of these been with you? Please tick the appropriate box for each staff member (some may require more than one tick)	How many of these are members of your family?
Total			
Owner operator		If <u>only</u> yourself, please skip to question 24	
Sharemilker		<1yr ☐ 1 – 2 ☐ 3+ ☐	
Farm manager		<1yr ☐ 1 – 2 ☐ 3+ ☐	
Herd manager		<1yr ☐ 1 – 2 ☐ 3+ ☐	
Farm assistant		<1yr ☐ 1 – 2 ☐ 3+ ☐	
Milk harvester/milker		<1yr ☐ 1 – 2 ☐ 3+ ☐	
Other (please specify)		<1yr ☐ 1 – 2 ☐ 3+ ☐	

18. If applicable, do your staff participate in any training? ☐ Yes ☐ No (please skip to question 20)

19. If Yes, what training have they participated in?..

....

20. Do your principal staff have a written job description(s)? ☐ Yes ☐ No (If No, please go to question 22)

21. Do these job descriptions include agreed performance targets? ☐ Yes ☐ No

22. How are these performance targets assessed? ……………………………………………………………………………………

………

23. Who is the main person responsible for the herd reproductive management in each of the 9 categories below: (write the persons' role in each box eg Herd manager)

(work down each column)	Prior to Mating	During AB period	During bull mating
Farm policy			
Takes charge of doing			
Does most of the doing			

24. Please enter your thoughts in the table below:

If you wanted to improve your herd's reproductive performance, what would you do?	Do you believe you and your workforce have the skills to do that?	Have you sought any outside input with this?	Unsure? (please tick)
a.	Yes or No	Yes or No	
b.	Yes or No	Yes or No	
c.	Yes or No	Yes or No	
d.	Yes or No	Yes or No	

25. In the last 3 years, have you made any changes to improve your herd's reproductive performance?

....

....

....

26. In the last 3 years do you think that your herd's reproductive performance has ☐ decreased ☐ stayed static ☐ increased?

How do you think that your herd's reproductive performance compares to other herds in this district?

☐ worse ☐ similar ☐ better

27. How do you assess that? ....

....

28. What is the main barrier to improving reproduction performance on your farm? ....

....

29. How likely is each of these to have been a constraint on your herd reproductive performance in the last two years?

	Very unlikely				Very likely
	1	2	3	4	5
AB and semen storage					
Anoestrus					
Body condition score					
Bull management					
Calving pattern					
Endometritis					
Heat detection					
Heifer size at calving					
Herd genetics					
Other (please specify)					

30. Have you heard of DairyBase? ☐ Yes ☐ No

31. Have you heard of Healthy hoof? ☐ Yes ☐ No

32. Had you heard of InCalf before the introductory meeting?

☐ Yes (If Yes, please complete the following questions) ☐ No (If No, please ignore the last question in this section)

33. If Yes, who did you hear about Incalf from? ....

This is the end of this section

We will now focus on herd information

Section 2

34. Which most resembles your production system (amount of imported feed)?

1. ☐ All cows on dairy platform for the year, no imported feed (**No feed is imported**, No supplement fed to herd **except** that harvested off the effective milking area)

2. ☐ Feed imported for dry cows or cows grazed off (~4 -14% of total feed is imported: Large variation in percentage as high rainfall and cold areas many cows are wintered off (e.g Southland)

3. ☐ Feed imported to extend lactation (typically autumn feed) and for dry cows (~10-20% of feed is imported, feed imported to extend lactation in spring rather than autumn (e.g. Westland)

4. ☐ Feed imported to extend BOTH ends of lactation and dry cows (~20 -30% of total feed is imported)

5. ☐ Imported feed used all year (~25-30% (even 55%) of total feed imported)

NB Farms feeding 1-2kgs of meal or grain/day for most of the season might best fit system 5.

35. When do heifers and cows calve in your herd?

☐ Spring only ☐ autumn only ☐ spring and autumn ☐ other (including year-round and extended lactation, please specify)..................................

36. Predominant breed

☐ Friesian ☐ Crossbred ☐ Jersey ☐ Ayrshire ☐ other (please specify)...

37. Which milking interval do you use?

☐ Twice daily ☐ once daily (full season) ☐ once daily (16 – 30 weeks of lactation) ☐ other (e.g. 3 times in 48hrs)

38. How many mobs do you most commonly run your milking cows in? ☐ 1 ☐ 2 ☐ 3 ☐ 4+

39. Do you irrigate (excluding effluent)? ☐ Yes ☐ No

40. Is your herd certified organic? ☐ Yes ☐ No ☐ Undergoing conversion

41. For **each dairy shed** within this farm, please complete the boxes below

Dairy number (or name)	Dairy shed type (rotary, herringbone etc)	Number of sets of cups

42. Within the **dairy shed** do you have any of the following? (Please circle)

Do you **have** any of the following?		Do you regularly **use** this technology?
In line milk monitors	Yes or No	Yes or No
Automated cup removal	Yes or No	Yes or No
Automatic drafting gates	Yes or No	Yes or No
Pedometer or activity meters	Yes or No	Yes or No
Automated weighing	Yes or No	Yes or No
Electronic identification (EID)	Yes or No	Yes or No
Computer assisted feeding	Yes or No	Yes or No

43. Could you give an **approximate area** for the following?

	Land Farmed	Area (hectares)
Total	Dairying area	
	Run-off and non-dairy	
Effective	Dairying area	
	Run-off	
	Non-dairy	

44. How **far away** is each run off? ....(km)

45. How many cows were milked at peak numbers in 2008/09? ....

46. What is your stocking density on the milking platform? ....

47. Please could you indicate how much supplementary feed that you were holding at the 1st of June 2008:

	How much on 1st June	How much was harvested from the dairy platform	How much was bought in	Unsure (please tick)
Grass Silage	☐ n/a			
Maize Silage	☐ n/a			
Palm Kernel	☐ n/a			
Turnip crop	☐ n/a			

Reproductive data for the **2008 / 09** spring calving season

48. How many cows calved during spring 2008? ....cows

49. How many of these were first time calvers? ....cows

50. What was your planned start of spring calving in 2008.(PSC)? 2008

51. How many spring-calving cows and heifers had calved by 21 days after PSC? ....cows

52. How many spring-calving cows and heifers had calved by 42 days after PSC? ....cows

53. How many spring-calving cows and heifers had calved by 63 days after PSC? ....cows

54. How many spring calving cows calved more than 63 days after the planned start of calving? ....cows

55. What date did the last spring-calving cow calve? 2008

56. Did you induce any cows in 2008? ☐ Yes ☐ No (If No, please go to question 58)

57. If Yes, please fill in the details in this table

Induction mob	When was this mob induced?	How many cows in this mob?
1	/2008	
2	/2008	
3	/2008	
4	/2008	

58. Approximately how many of your calvings in 2008 required assistance from either farm staff or the vet?

....

59. Did you have cows examined for uterine infections (e.g. metricheck) in the 2008/09 season? ☐ Yes ☐ No (If No, please skip to question 63)

60. When did this occur? 3 to 5 weeks before mating ☐ <3 weeks before mating ☐ after PSM ☐

61. How many cows were checked? ☐ Whole herd ☐ 'at risk' cows only (number) ....

62. How many cows were treated for uterine disease? ....

63. What value do you place on metrichecking?

☐ Low benefits for my herd ☐ ☐ Moderate ☐ ☐ High benefits for my herd

63. How many cows had the following conditions in the 2008/09 season?

	How many cases?	Please tick if no records of the disease were kept
Retained cleaning (i.e. membranes present > 1 day after calving)		
A dead (stillborn) calf (premature precalving death)		
Clinical mastitis that required treatment up to the end of mating		
Lameness (i.e. not fully weight bearing on one or more legs and not walking normally) up to the end of mating		

64. In 2008/09, did you pregnancy test the ☐ whole or ☐ part of the herd?

65. When were the cows pregnancy tested: date 1 .... date 2 ....date 3 ....

66. What method was used? ☐ Manual palpation ☐ ultrasound scan ☐ other (e.g. ballotment)

67. What information did you get from pregnancy testing? ☐ 'Yes'/'no'/'late' only ☐ some dated ☐ all dated

68. What was your empty rate? ....

69. Are you planning to pregnancy test your whole herd in 2009/10? ☐ Yes ☐ No

In 2008/09:

70. What was your planned start of mating (PSM) for your spring calving cows? ..../............/ 2008

71. What was your planned start of mating (PSM) for your spring calving heifers? ..../............/ 2008

72. Number of cows submitted at least once in 21 days (3 weeks) from PSM? ....cows

73. How many cows were inseminated throughout the AB period? ....cows

74. Who was responsible for **heat detection** on the farm **in 2008/09?**

☐ Sole charge ☐ All staff ☐ one appointed member of staff ☐ other (please specify)............................

75. Heat detection was carried out

☐ In the dairy shed and yards ☐ in the races ☐ in the paddock ☐ both

76. **Heat detection** was performed

☐ Once daily ☐ twice daily ☐ three times daily ☐ more often

77. If tail paint or heat detection aids were used, **when were these put on?**

☐ 6 weeks before PSM ☐ between 6 and 4 weeks before PSM ☐ between 4 and 1 weeks before PSM ☐ 1 week before PSM ☐ at PSM

78. How much **training** had the heat detection observer(s) received?

☐ External tuition ☐ Formal protocol on farm ☐ preseason run through ☐ expected or assumed prior knowledge

☐ learned on the farm ☐ other (please specify ....) ☐ none

79. Selection of cows to be **inseminated** is based on

☐ Tail paint removal only ☐ heat detection aid (e.g. Kamar) ☐ observed standing to be mounted

☐ combination of these ☐ other (please specify) ....

80. In 2008/09, did you use **hormonal treatments** (e.g. CIDRs or $PGF_{2\alpha}$) on you non cycling cows? ☐ Yes ☐ No (If No, please skip to question 88)

81. **How many cows** were presented for this treatment? ....

82. When were these cows treated?

☐ Before PSM ☐ within the first 21 days after PSM ☐ between 21 to 28 days after PSM ☐ end of AB period ☐ combination

83. **What date** was this first (or only) mob treated with this treatment? ..../............./ 2008

84. If applicable, what dates were **subsequent mobs treated?** ..../............./ 2008 ..../............./ 2008 ..../............./ 2008

85. Were these treated cows served to ☐ **observed oestrus** or ☐ **fixed time AB** or a combination of ☐ **both?**

86. Were any of these cows resynchronized? ☐Yes ☐ No

87. Do you intend to treat a similar number this year? ☐ Less ☐ Same number ☐ More

88. Did you use bulls alone to stimulate or inseminate your non-cycling cow mob? ☐ Yes ☐ No (please go on to question 91)

89. Were these bulls ☐ entire or ☐ vasectomised ('teasers')?

90. If yes, when were these bulls introduced to the non-cycling cow mob relative to the PSM? ……………………………………………………………

91. Who performs AI in your herd?

Professional technician (name and company if possible)……………………………………………………………………………………………

(If a professional technician is used, please skip to question 92)

DIY (if so who?)………

If applicable, how is semen stored? …………………………………………………………………………………………… ☐ n/a

If applicable, how is semen thawed? …………………………………………………………………………………………… ☐ n/a

92. What is your emphasis when selecting semen? ☐ Production worth ☐ reproductive worth ☐ pedigree ☐ proven sire/'bull of the day'

93. What date did AB finish? ………/…………/ 2008

94. What date were the bulls withdrawn from the spring calving cows? ……………………………………………………………2009

95. In 2008/09, did you weigh your heifers? ☐ Yes ☐ No (If No, please go to question 100)

96. If Yes, then how often? ☐ Once a year ☐ twice a year ☐ about every three months ☐ more frequently

97. What (if any) were your heifer calves target weights at weaning ……………………(kg) and heifers before first mating? ……………………(kg)

98. Were these targets met? ☐ Yes ☐ No

99 What management practices are set in place if these targets are not met?

☐ Hold back ☐ preferentially fed ☐ sell ☐ cull ☐ other (please specify) ……………………………………………… ☐ none

100. In 2008/09, did you body condition score and record this for your cows? ☐ Yes ☐ No (If No, please go to the next section)

101. If yes, when were the cows body condition scored?

	Yes	No	What was the average BCS
1 to 4 weeks before the PSC			
1 -2 weeks before PSM			
End of mating			
In late lactation			
Other times (please define)			

NB if cattle are body condition scored more frequently, please could you enter the herd average for each of the above times

102. Was this done by the ☐ farm team or by ☐ another impartial person (please specify)..

103. How was the BCS done? ☐ 'Hands on' ☐ visual assessment

104. How many cows are body condition scored each time? (Please give the total of all the mobs that were scored) ....

This is the end of section 2, the final section asks about disease and stock movement

Stock movement and disease control

105. For each class of stock, please use the table below to indicate the status of stock movement off your farm and back

(please tick)	Did NOT leave the farm	Went away and completely isolated	Went away but may have had nose to nose contact with other stock over fence	Mixed with stock from other farms	Stock went away to shows
Calves					
Heifers					
Cows					
Carry-over's ☐ n/a					

106. Were calves from heifers kept as replacements or for beef? ☐ Yes ☐ No

107. Were calves (including beef calves) kept from any cows that go off the farm during their first 4 months of pregnancy?

☐ n/a ☐ Yes ☐ No

108. Were calves (including beef calves) kept from any carry-over cows? ☐ n/a ☐ Yes ☐ No

109. If calves did go out grazing, when did they leave the farm? ☐ n/a 2008

110. Which term best describes your calf management after weaning in 2008/09:

- ☐ A few to a paddock in contact with milking herd
- ☐ Mob(s) rotationally grazed in front or behind the milking cows
- ☐ Calves always grazed separately from cows (no common grazing of calves and cows)
- ☐ Other (please explain): ....

111. Were calves ever grazed together with cows on a hospital paddock? ☐ Yes ☐ No ☐ n/a

112. How many bulls came on to this farm for the first time in the last 12 months? .... (If none, please go to question 122)

113. How many were: calves .... yearlings .... 2-year-olds .... 3-year-olds .... 4-year-olds .... older ....

114. What breed were the bulls? ☐ Jersey ☐ Hereford ☐ Angus ☐ Friesian ☐ other (please specify)..

115. Were the bulls: ☐ Born on the farm ☐ Bought ☐ leased or borrowed

116. How long did/will these breeding bulls stay on the farm?

☐ Mating period only ☐ 2 or 3 years ☐ 4 or more years

117. Were these bulls tested for BVD antigen?

☐ Before arriving ☐ after arriving ☐ not tested ☐ unknown

118. Were these bulls tested for any other infectious disease? ☐ Yes ☐ No

If Yes, please specify ....

119 Were bulls run together before mating? ☐ Yes ☐ No

116. If yes, for how long? ....

120. Up to how many of these bulls were in with the milking cows at any one time (for mating)? ....

121. Were the bulls swapped in & out regularly (i.e. every 1-3 days)? ☐ Yes ☐ No

122. How many cows were brought onto this farm from another farm (e.g. bought, borrowed or leased)?

In the 2008/09 season.. in the 2009/10 season.. (If none, please go to question 126)

123. Were these cows tested for BVD virus? (Please tick)

☐ Tested all ☐ Tested some ☐ Tested none

124. Were these cows tested for any other infectious disease? ☐ Yes ☐ No

126. If Yes, please specify ....

125. Were calves kept from any of these cows? ☐ Yes ☐ No

126. How many carryovers did you retain from the previous season? .... (If none, please go to question 129)

127. Would this be approximately ☐ more ☐ less ☐ or the same as previous years?

128. When new stock arrive or your stock arrive back onto the farm after grazing off, are they kept separate (quarantined) for 3 weeks or more from any cows that remained at home? ☐ Yes ☐ No

129. How many paddocks are there on your milking platform? ....

130. How many of these paddocks could allow nose to nose contact with neighbours stock? ....

131. How many neighbouring properties allow nose to nose contact? ....

132. If and when contact occurs, how many cattle actually show interest in the contact?

☐ Don't know ☐ No contact ☐ few (1 – 5) ☐ some (6 – 20) ☐ many (>20) ☐ Whole herd

133. Of all classes of stock on the farm, are any vaccinated for the following diseases?

	BVD	IBR	Blackleg (*Clostridia*)	*Leptospirosis*	others
None					
Cows					
Heifers					
Calves					
Bulls					
New-comers ☐ n/a					

134. How many abortions were there last year? ....

135. Have you had a case of BVD diagnosed in any of your stock before? ☐ Yes ☐ No (If No, please finish up with the last question)

136. If Yes, what year was the last case diagnosed? ....

137. Having shared your time and information, is there anything that you think that has not been asked that you think might be relevant?

……

……

……

Thank you for sharing your time and completing this questionnaire

Appendix 2