AGRICULTURAL RESEARCH INSTITUTE OF NORTHERN IRELAND

Dairy Herd Fertility - Examination of Effects of Increasing Genetic Merit and other Herd Factors on Reproductive Performance

End-of-Project Report to AgriSearch
April 2002

Department of Agriculture and Rural Development

AgriSearch NI Farmer Funded Research

Dairy Herd Fertility - Examination of effects of increasing genetic merit and other herd factors on reproductive performance

C.S. Mayne, M.A. McCoy, W.J. McCaughey,

E.A. Goodall and F.J. Gordon

Report prepared by D.R. Mackey

End of project technical report presented to AgriSearch

April 2002

SUMMARY

- Results from this project clearly show that infertility is a major problem in Northern Ireland dairy herds, where it is the cause of considerable financial loss.

- A key recommendation from this project is that there is a major requirement to radically review the methods used to assess fertility status in dairy herds. New methods should:
  1) Be meaningful and easily understood
  2) Be applicable across all farms (for between farm and between year comparison)
  3) Facilitate timely assessment of fertility performance, i.e. during the breeding period

- It is proposed that In-Calf Rate should be adopted by dairy farmers in Northern Ireland to assess the reproductive performance of their herds, i.e:

  a) 6-week in-calf rate for herds with a compact seasonal calving pattern
  Proportion of cows intended for re-breeding that are in-calf 6 weeks after the start-date of breeding season.

  b) 100-day in-calf rate for herds with a prolonged calving period
  Proportion of cows intended for re-breeding that are in-calf within 100 days of calving. This measure is applicable to most dairy herds in Northern Ireland.

  Both measures are directly comparable as the 6-week (or 42 day) in-calf rate assumes a voluntary waiting period of 58 days, or just over 8 weeks, when conception rates have reached their plateau.

  A further measure, 200-day Not-In-Calf Rate, indicates the proportion of cows not in calf within 200 days, and which are likely to severely reduce the overall reproductive performance of the herd.

- Targets for Northern Ireland dairy farmers should be:
  1) 100-day In-Calf Rate of greater than 40%
  2) 200-day Not-In-Calf Rate of less than 20%

These targets are currently being achieved in Northern Ireland dairy herds with the best reproductive performance.

- Key strategies to achieve these targets involve focusing on both submission rate and conception rate.

1. Submission Rate

This can be increased by:

a) Commencing heat detection four weeks prior to the planned start of breeding

b) Using effective heat detection procedures
e.g. frequent observation (4-5 times per day with 20 minutes per session), tailpaint, or perhaps other methods

c) Identifying and treating anoestrus cows early (i.e. those not observed in heat by day 42 post-calving)
(Note: 27% of dairy cows have delayed ovulation in the post-calving period)

d) Inseminating cows early (i.e. from day 56 post-calving)

Adhering to these procedures will result in a higher proportion of cows being submitted for service.

2. Conception Rate

This can be increased by:

a) Controlling the condition of dry cows (i.e. body condition score of less than 3.0 but greater than 2.0 at calving)

b) Avoidance of excessive liveweight and body condition loss in early lactation by maintaining high dry matter intakes

c) Avoidance of major dietary changes during the breeding period

d) Using a good AI technique (including semen storage and handling) or using a trained inseminator.

The above procedures will result in a higher proportion of cows conceiving to a specific insemination.

INTRODUCTION

Poor reproductive performance is a major problem on dairy farms throughout the United Kingdom (UK) and has been identified as the single most important problem in dairy herd management in Northern Ireland (AgriSearch Farm Survey). In addition to the direct financial cost, estimated at over £500 million per annum in the UK (equivalent to £52.5 million per annum in Northern Ireland), infertility can result in increased management complexity as a result of inability to achieve a compact calving pattern. This is a particular problem in seasonal production systems where compact block calving is of critical importance in maximising milk production from grazed grass.

A number of recent studies have reported substantial declines in the reproductive performance of dairy herds worldwide. For example in the United States, it is estimated that conception rate to first service has declined by 14% between 1960 and 1995, while recent data from the UK suggests an even greater decline with a decrease in conception rate to first service of 20%, to approximately 40%, over the last 20 years. While reproductive performance is influenced by a large number of factors, including management practices and nutritional factors, the decline in dairy cow fertility is also associated with an increased genetic capacity for milk production. This has been attained largely through substitution of the British Friesian by the North American Holstein, the percentage of Holstein genes in the UK dairy herd rising from 0% in 1975 to approximately 80% in 1998.

The association between increasing 'Holsteinisation' and declining fertility is not confined to the UK, as similar observations have been reported in the Republic of Ireland, the Netherlands and New Zealand. However, declining herd fertility may not be entirely attributable to the increasing proportion of Holstein genes. Conception rates in non-lactating Holstein heifers in the US have remained high (70-80%) during a period when milk production per cow increased by 218%. Thus, whilst there is some evidence of a genetic trend towards lower herd fertility, the major decrease observed at farm level may also be due to other factors. These include management changes such as increased herd size and also the increased incidences of severe negative energy balance (NEB) in early lactation, associated with higher milk yields and insufficient nutrient intake.

Against this background, a major research programme was initiated at Hillsborough in 1998 with the objective of collating a comprehensive database on milk production and reproductive performance from a range of dairy herds in Northern Ireland in order to identify the key factors influencing reproductive performance at farm level. The objectives of study were to:

- To establish causes of severe dairy herd infertility and to develop suitable management and/or intervention procedures to improve fertility in these problem herds.
- To obtain data on reproductive performance from dairy farms across Northern Ireland and to use these data to identify key factors influencing reproductive performance at farm level.
- To develop management strategies to improve reproductive performance and to evaluate these strategies on a number of commercial dairy herds in Northern Ireland.

MATERIALS AND METHODS

In order to meet the objectives, the study comprised three parts.

1. In-depth investigation of problem herds

Twelve dairy herds experiencing, or having recently experienced, acute infertility problems were identified by veterinary practitioners, advisers or owners. The nature of the problem was discussed with the owner and cow condition, general housing, feeding and herd management were examined. Breeding records were collected and analysed to estimate heat detection rates and to assess the effects of interval from calving to service, parity, season and breeding policy on conception rate. Where appropriate, more detailed assessments were made, including rectal palpation of cows, metabolic analysis and disease surveillance of blood samples, progesterone analysis of milk samples and assessment of feed samples for nutritive value.

2. Herd monitoring studies

In autumn 1998 a large-scale monitoring study was initiated involving 19 herds of Holstein-Friesian cows (approximately 2500 cows), spread geographically across Northern Ireland. The herds were selected to represent those throughout the region and included a wide range of herd size, concentrate input, feeding methods, genetic merit, level of milk production, calving pattern and labour input. A comprehensive range of data on herd management, performance and reproduction in the 19 herds over two years was established through the collaboration of farmers, local veterinarians, Institute technical staff and other agencies. Information collected included:

- <u>Health and reproductive records</u>

  Detailed records of cow health and reproductive performance of individual cows were provided by herd-owners. Calving records included details on the type of calving (unobserved, unassisted, assisted without calving aid, assisted with calving aid, vet-assisted or caesarean) and on the type of calf (single/twin, bull/heifer, live/dead). Heat records contained details on the type of heat (observed standing, demonstration of signs indicative of heat or detected via tail paint, Kamars, etc) while service records contained details on the type of service (DIY-AI, company-AI or natural service) and name of bull. Records on removal of cows from the herd were divided into six general categories (infertility, lameness/locomotion/skeletal, mastitis/injury to teats or udder, other diseases/ill thrift/found dead, individual cow management problems, or general management decisions), each with their own subdivisions.

- Production information

  The milk records of individual cows, both monthly and complete lactation, were made available through the milk recording agencies.

- Genetic merit information

  Pedigree details of individual cows (on a PIN_{2000} base) were obtained through the co-operation of herd-owners and Holstein UK and Ireland. For cows not pedigree registered, details of sire and maternal grand-sire were obtained and an estimate of cow genetic merit was applied using current bull (PIN_{2000}) values.

- Milk progesterone

  During a 14-week period, associated with peak calving incidence on each farm, milk samples were collected twice weekly (at 3 or 4 day intervals) from recently calved cows. These were analysed for progesterone and used to establish the interval to commencement of luteal activity (indicative of the resumption of oestrous cycles) and the heat detection rate. In addition, progesterone profiles were assessed as either normal, with regular occurrence of oestrous cycles, or atypical, where one or more abnormalities occurred, as shown in Figure 1. Essentially these were defined as:

  Delayed ovulation type I (DOVI). Delayed resumption of cyclicity after calving, where milk progesterone concentrations remained low for more than 45 days post calving.

  Delayed ovulation type II (DOVII). Resumption of cyclicity after calving but then lapsing into anoestrous, where milk progesterone concentrations remained low for more than 12 days following earlier commencement of luteal activity.

Persistent corpus luteum type I (PCLI). Delayed luteolysis of the corpus luteum that developed from the first post-calving ovulation, where milk progesterone concentrations remained high for more than 19 days.

Persistent corpus luteum type II (PCLII). Delayed luteolysis of the corpus luteum that developed from the second or a subsequent post-calving ovulation, where milk progesterone concentrations remained high for more than 19 days.

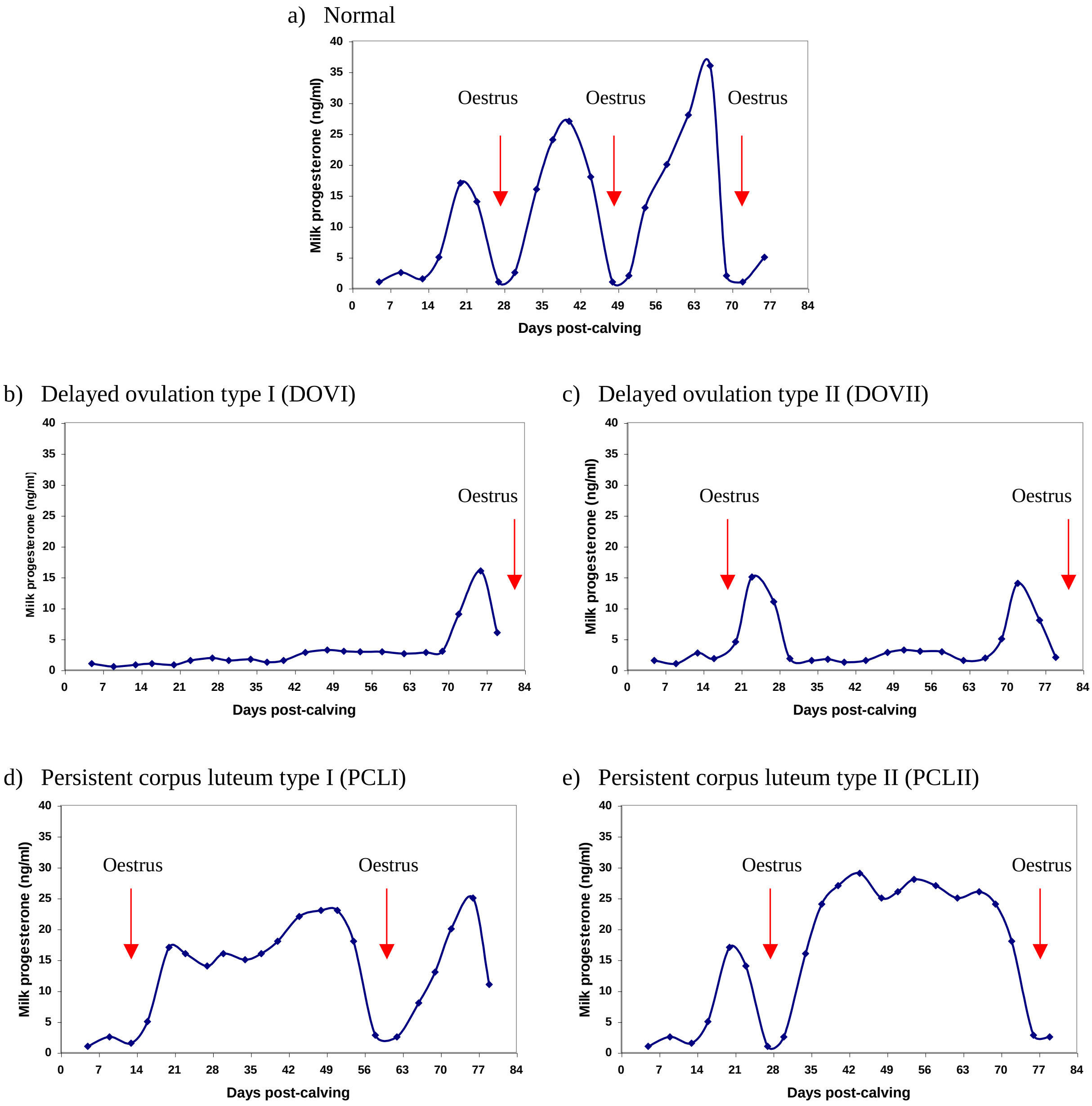


Figure 1 *Classification of milk progesterone profiles*

- Body condition score

  All cows in the study were body condition scored (BCS) three times per year by Institute staff, the timing of which was co-ordinated in relation to the calving period in each herd. The aim of this was to achieve a pre-calving score for as many cows as possible, together with two scores during lactation, one during the first 14 weeks of lactation.

- Feed records

  Feed inputs on each farm were recorded on at least one occasion in early lactation. Samples of winter forages and concentrates were taken for analysis and, following laboratory analysis, estimates of dry matter intake were calculated. Details of turnout to grass, type of grazing system and date of re-housing were recorded and pre- and post-grazing grass samples and sward heights were taken three times per season. Together with milk records, these records allowed an estimation to be made of the overall energy balance of cows within each herd in the first 100 days of lactation.

- Labour availability and veterinary costs

  Information on the level of stockmanship on each farm was also collected. The number of labour units available on each farm was recorded and adjusted to that required per 100 cows and per million litres of milk produced.

All data were collated on a central database and validated. An assessment of fertility was made for the first two years of the study, i.e. cows that calved in the period from 1st August 1998 to 31st July 1999, and from 1st August 1999 to 31st July 2000. In each year, either a subsequent calving or removal from the herd completed the record for individual cows.

The fertility parameters investigated were:

a) Heat detection rate:

   Heat detection rate was determined by comparison of observed heats with those identified from analysis of progesterone profiles. In addition, heat detection rate for each herd during the main breeding season was also estimated using information from recorded inter-heat intervals.

b) Interval to first service:

Interval from calving to first recorded service.

c) Conception rate:

Firstly, the estimated conception rate based on the 60-day non-return rate (60-day NRR) was calculated as the percentage of cows that did not return to heat within 60 days of service. Subsequently, conception rate was calculated using the following equation, where confirmation of in-calf was based on a subsequent calving or positive pregnancy diagnosis prior to removal from the herd. Total number of services included services for all cows that subsequently calved or were removed from the herd.

$$\text{Conception rate} = \frac{\text{Total number of cows confirmed in calf}}{\text{Total number of services (all cows)}} * 100$$

d) Calving interval:

This was defined as the interval between two successive calvings for individual cows, with minimum and maximum calving intervals based on gestation lengths of 260 and 299 days respectively. Cows with gestation lengths less than 260 days were assumed to have aborted and a calving interval was not calculated unless a viable calf was produced. Cows with gestation lengths greater than 299 days were assumed to have conceived to a subsequent non-recorded service.

e) Removal rate:

This was defined as the proportion of cows removed from the herd as a percentage of the cows that calved in that particular year.

For each herd an objective assessment of season and compactness of calving was conducted each year to establish the calving pattern. The cumulative number of cows that calved each day throughout the year commencing 1st August was calculated. The proportion of autumn-calving cows in each herd was defined as the percentage of cows that had calved by 1st January 1999. Compactness of calving was assessed for each herd using a 12-week rolling average and was defined as the percentage of cows calving in the busiest 12-week period.

Following the calculation of fertility parameters for each herd, herds were ranked according to heat detection rate, conception rate to first AI or calving interval. For each of these parameters, herds were grouped into high, medium and low categories. These groupings were used to examine the effect of cow, diet, production and labour availability factors between high and low groups of herds, each comprising 6 herds.

3. Management strategies to help improve reproductive performance

Three intervention programmes were launched in autumn 2001 involving all 19 monitor herds. All three programmes are currently on-going and are described briefly as follows:

a) <u>Data management intervention – 6 participating herds</u>:

A major finding from the herd monitoring studies was that many herd owners had difficulty fully analysing their herd records during the breeding period. In response to this, a Fertility Management Program was specifically developed for this project. The programme involves farmers faxing details of calvings, heats, services and cows intended for culling to Hillsborough three days per week. These data are input to the computer program, which in response produces an action list of cows anticipated to be in heat, a warning list of cows not yet seen in heat and a progress monitor giving details on both submission rates and non-return rates to service. This output is returned by fax to the participating farmers within one hour of receiving the input information.

b) <u>Nutritional intervention – 2 participating herds:</u>

It is widely recognised that energy deficit, or negative energy balance, of dairy cows in the postcalving period is associated with poor levels of fertility. Consequently, there has been considerable interest in developing strategies to increase the energy intake of the dairy cow during this period, in order to limit this negative energy balance. A recently developed high energy supplement (Energise) has given promising results in studies in commercial herds in England (Anon, 2002). This high-energy supplement, fed at approximately 1 kg per cow per day, is designed to reduce the degree of negative energy balance and body condition score loss in the early postcalving period, thereby aiming to improve reproductive performance. As part of the current project, this product is being evaluated on two of the monitor herds.

c) <u>A.I. technique – 6 participating herds</u>:

Do-it-yourself (DIY) AI has been widely adopted throughout the Northern Ireland dairy industry. However, in a recent Australian study involving 128 herds, conception rate to DIY inseminations was 3% lower than that of inseminations conducted by a professional inseminator. However, there was tremendous variation between herds, with conception rates to DIY-insemination ranging from 36% less than that of a professional inseminator to 14% more as shown in Figure 2. Indeed, 45% of farmers in this Australian study could improve their conception rates by 5% or more if optimal AI practices were used. In order to identify if DIY technique is a problem in dairy herds in Northern Ireland, a study was initiated in 6 of the monitor herds which normally use DIY-AI. In these herds, the insemination of cows was conducted on an alternate-day basis, with DIY-insemination continuing to take place on one day with insemination by a professional technician (AI Services) taking place the next. All services were conducted using semen from the farmers' own flask. All cows were milk-sampled for determination of progesterone concentration at the milking following insemination.

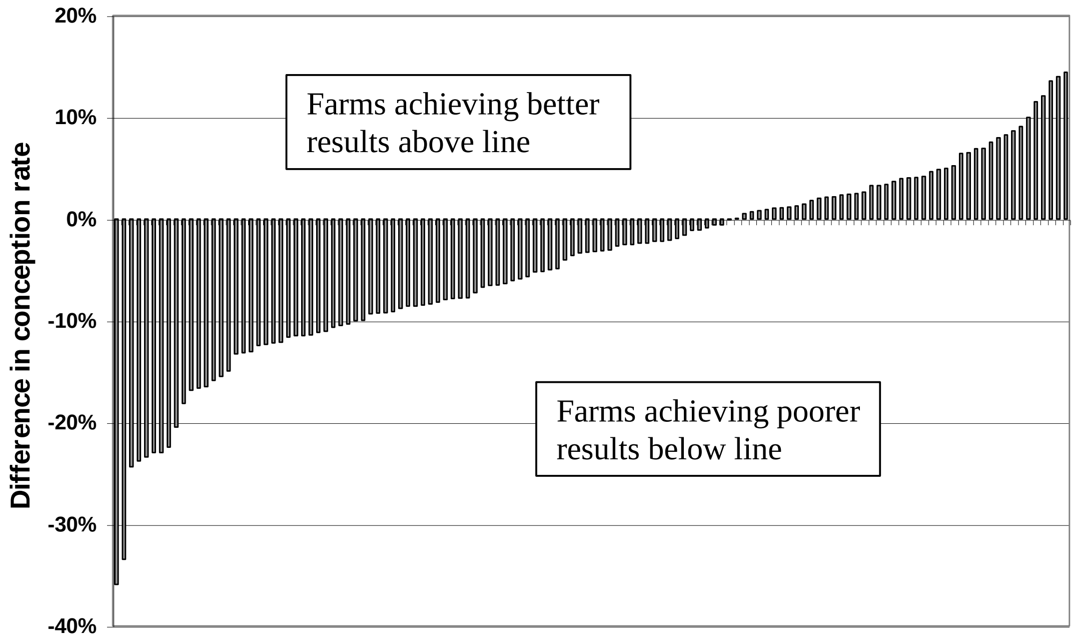


Figure 2 *Differences in conception rate between inseminations performed by 128 dairy herdspersons and by "professional" AI technicians (Morton, 2000)*

RESULTS

1. In-depth investigation of problem herds

This investigation began with the study of 12 herds, but only the results of 10 are reported on. Of the two remaining herds, one was small (12 cows) and a decision was made to go out of dairy production, while the other had undergone an extensive regime of treatments and was overcoming the infertility problem.

In the 10 herds that underwent thorough investigation, results indicated that there is no apparent single predominant cause of acute infertility in Northern Ireland dairy herds. Indeed, a range of causes were identified (Table 1). In most cases the problem was not identified for some time after the cows had failed to conceive, and therefore only presumptive diagnoses could be achieved.

Table 1 *Summary of conclusions of fertility investigations on 10 dairy farms*

Herd no.	Herd size	Group affected	Presumptive problem
1	120	Heifer group	Inadequate protein intakes.
2	130	High producing cows	Poorly fermented silage. Underfeeding.
3	120	All cows	Liver fluke. Poor heat detection.
4	110	Inseminated cows	Poor insemination technique.
5	124	All cows	Inadequate lighting for heat detection.
6	140	Early calvers	Poorly fermented silage.
7	100	All cows	Inadequate protein intake. Poor AI technique.
8	90	All cows	Potential low intakes of silage.
9	100	Periodic short lapses	Problem not identified.
10	115	All cows	Inadequate time allocated for heat detection.

The underlying problems associated with infertility in the majority of herds investigated were essentially delayed and inadequate analysis of herd breeding records, over-estimation of forage nutritive value and management changes/alterations. The following is a summary of the main factors that contributed to infertility in the ten ‘problem’ herds:

- ***Inadequate nutrition***, primarily associated with poor quality silage fed during the winter of 1998 on many of the farms investigated.
- ***Endometritis*** associated with poor hygiene at calving and at service on some farms. On these farms nutrition in early lactation was found to be inadequate and this may well have lowered immune function and the cows' ability to clear infections.
- ***Poor heat detection*** in two herds, one of which only conducted heat detection at milking time (i.e. twice daily), and in the other, a rebuilding programme had reduced light intensity and created areas where cows could not be easily seen.
- ***Poor AI technique*** in one herd, where semen storage and handling and AI technique were suspect.
- In one herd no cause was identified.

2. Herd monitoring studies

A comprehensive database on herd characteristics, genetic merit, concentrate intake and milk production was established, as summarised in Table 2.

Table 2 *Range of herd characteristics, genetic and production parameters between the 19 herds*

	Average	Range
Herd characteristics		
Herd size (no. cows)	130	50-223
Purchased concentrate (kg/cow/year)	1550	235-2960
Genetic parameters		
PIN_{2000} (£)	4.4±0.3	-5.0-15.9
Milk production (305-day)		
Milk yield (kg/cow)	7463	4871-10677
Milk protein (%)	3.25	3.11-3.45
Milk fat (%)	3.78	3.50-4.16
Calving pattern		
Autumn calving (%)	46.0*	11.8-81.8
Compactness (% of cows calving in busiest 12-week period)	54.2*	29.8-80.2
Labour availability		
Labour units/100 cows	1.3*	0.8-2.0
Labour units/million litres	1.7*	1.1-2.4

*****Between herd average

In the first year of the study a total of 2474 calvings were recorded in the 19 herds with an average of 130 cows calved per herd (range 51-225), while during the second year of the study 2535 calvings were recorded with an average of 133 cows calved per herd (range 55-205). There was considerable variability in the calving patterns of the 19 herds as seen in Figure 3, ranging from autumn and spring block calving through to all-year round calving.

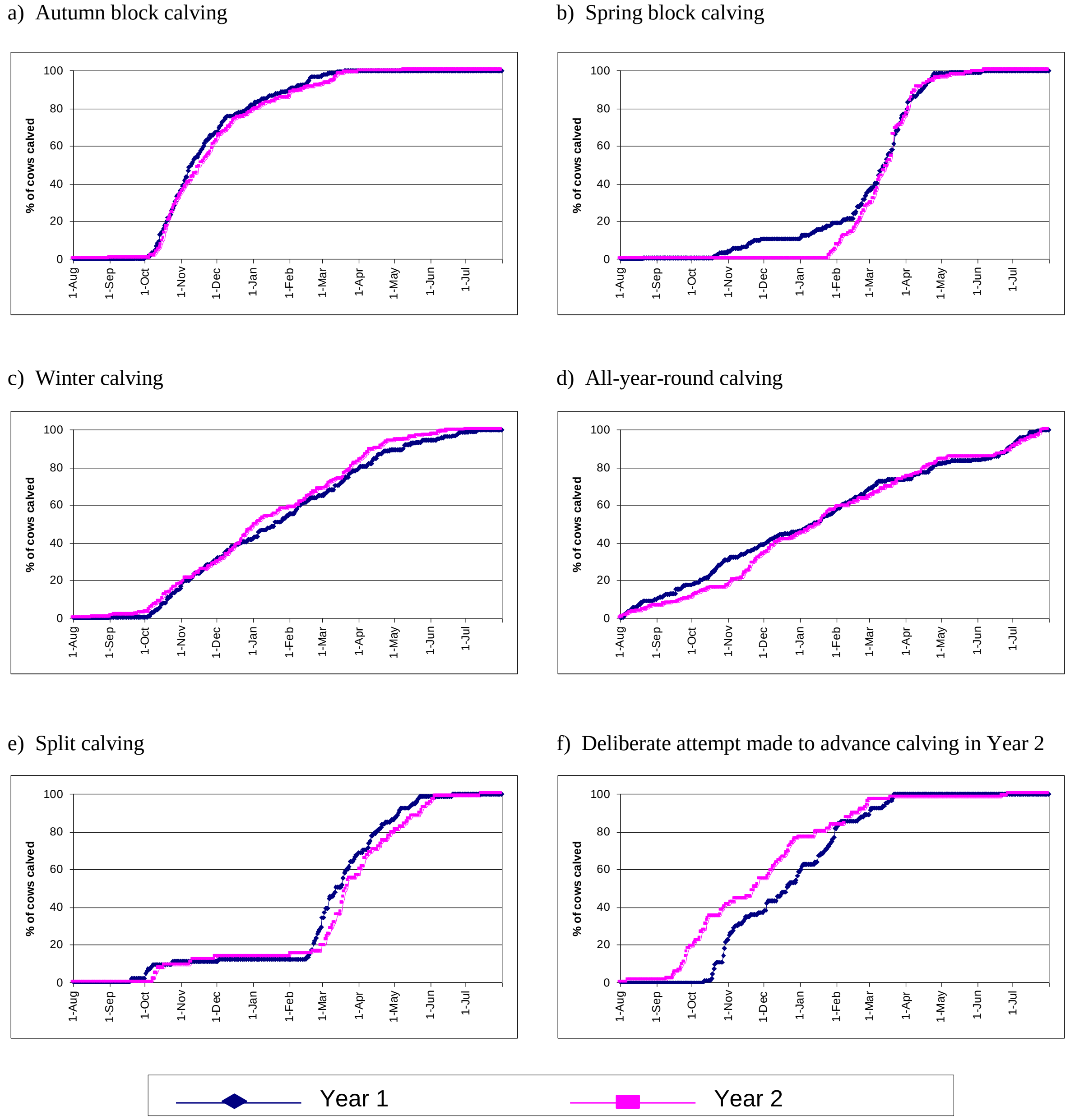


Figure 3 *Typical calving patterns observed in the study*

Assessment of the fertility parameters in the 19 herds over the two years established that there was a wide degree of variation between herds. This is demonstrated in Figure 4 where, for the 19 herds in each year, the three primary fertility parameters were independently ranked from lowest to highest. There was considerable variation in the ranking of herds for each parameter between years. This is demonstrated in Figure 5 where, for the 19 herds, each fertility parameter was independently ranked from the herd with the greatest decrease to the herd with the greatest increase. While not presented in Figures 4 or 5, the average interval to first service among the 19 herds in year 1 was 84 days (range 67-118 days between herds) while in year 2 it was 86 days (range 68-129 days between herds). However, within herds, there was considerable variation between cows in the interval to first insemination.

The effect of cow, production and management factors on fertility

Results, based on the stratification of the three main cow fertility parameters into low and high categories, are presented in Table 3, with the main findings discussed below.

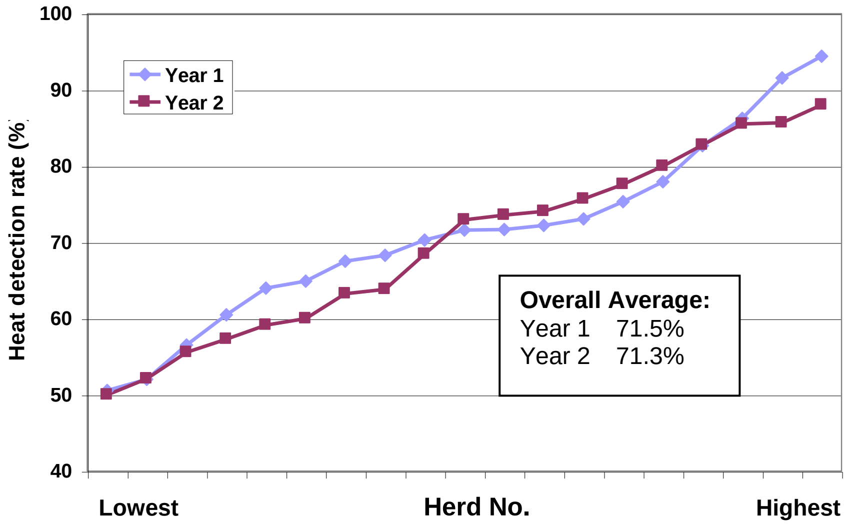
Heat detection rate

The average estimated heat detection rate across the 19 herds was 71% in both years 1 and 2, based upon inter-heat and inter-service intervals. In year 1, the highest heat detection rate was in a herd where 94% of all regular returns during the main breeding period were recorded, while in year 2 a different herd recorded 88% of regular returns. Herds with high estimated heat detection rates (84.2 v 58.7%) had significantly shorter calving intervals ($P=0.01$) and significantly ($P<0.05$) lower 305-day protein yields, postcalving body condition loss, negative energy balance in early lactation and concentrate feed levels as shown in Table 3.

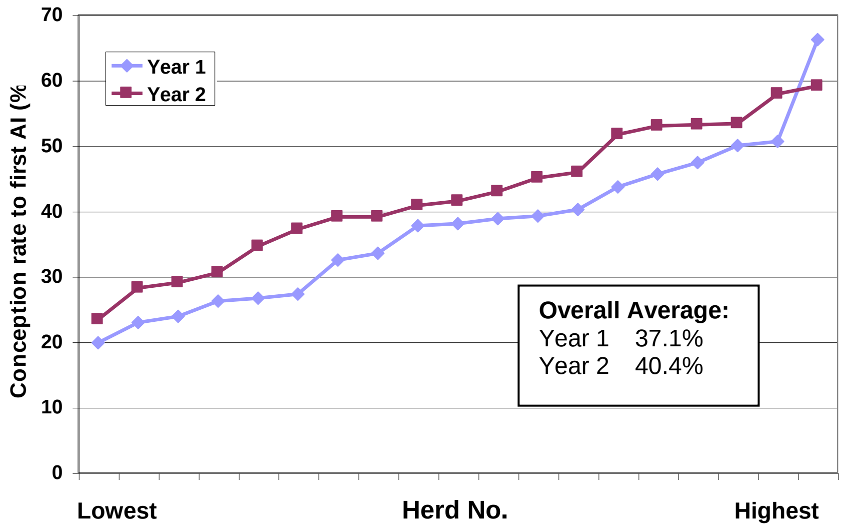
Conception rate to first insemination

The average conception rate to first insemination across the 19 herds was 37.1% in year 1 and 40.4% in year 2, though there was much variation between herds as shown in Figure 4 (range 20-66%). Herds with higher conception rates to first insemination (50.8 v 24.6%) had significantly higher DM (20.4 v 16.6; $P<0.01$) and ME (233 v 195 MJ ME/d; $P<0.01$) intakes in the first 100 days of lactation and higher levels of production (Table 3). They also had a higher proportion of autumn calving cows (55 v 31%; $P<0.05$). Average genetic merit of herds was similar between high and low conception rate groups.

a) Heat detection rate



b) Conception rate to first service



c) Calving interval

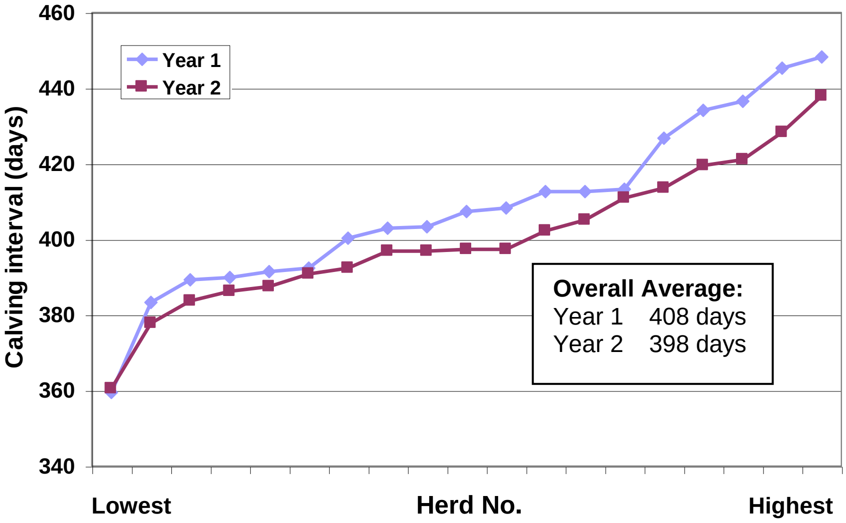


Figure 4 *Ranking of the three primary fertility parameters among the 19 herds in years 1 and 2 of the study*

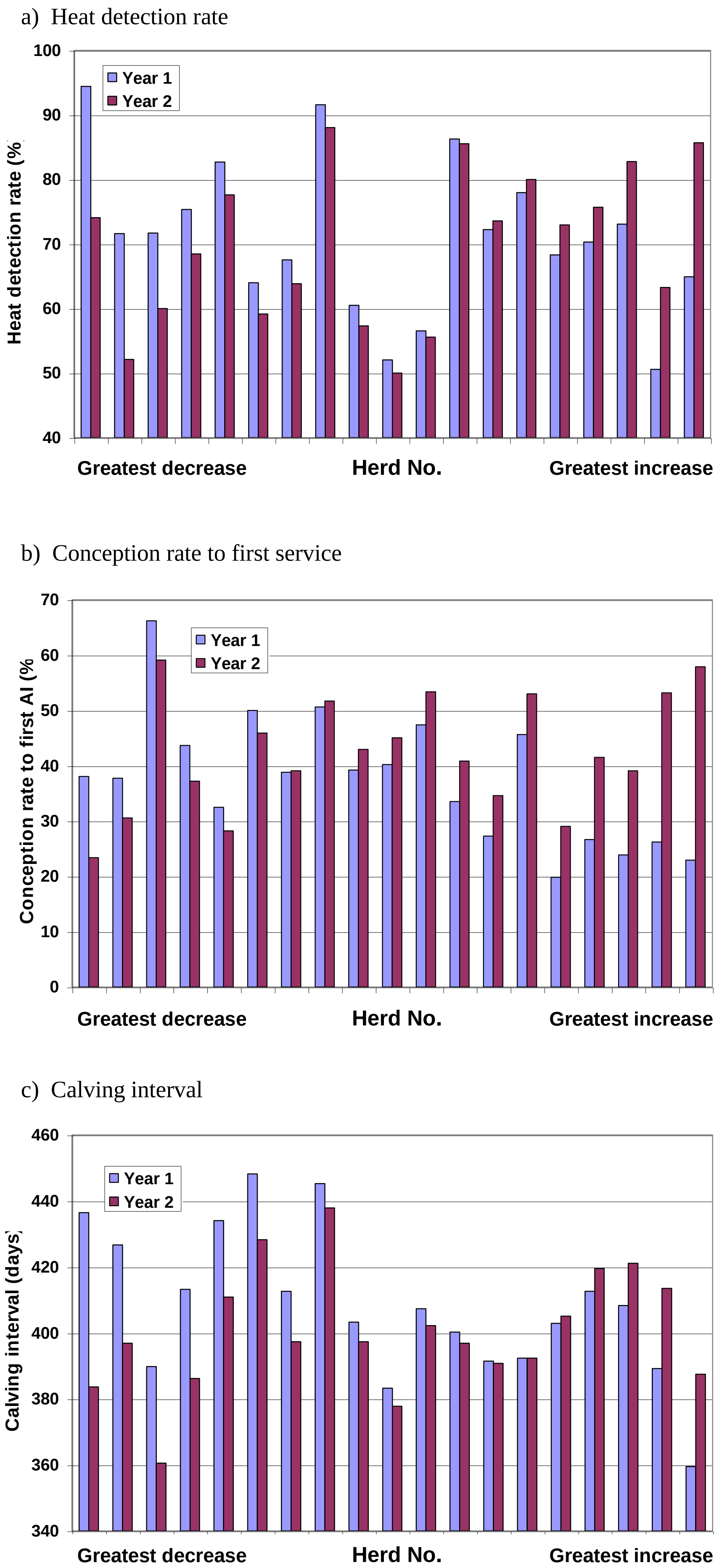


Figure 5 *Change in the reproductive performance of the 19 herds between years 1 and 2 of the study, as assessed by the three primary fertility parameters*

Calving interval

The average calving interval across the 19 herds was 408 days in year 1 and 398 days in year 2, but again there was much variation between herds as shown in Figure 4 (range 360-448 days). Herds with shorter calving intervals (383 v 430 days) had significantly higher heat detection rates (83 v 61%; $P<0.01$), had a shorter interval to first AI service (74 v 97 days; $P<0.05$) and a lower removal rate (23 v 37%; $P<0.01$). Herds with shorter calving intervals also had lower body condition scores in the dry period prior to calving (3.0 v 3.3; $P<0.05$), less body condition loss in the postcalving period (0.3 v 0.6, $P<0.05$) and less negative energy balance in early lactation (1.8 v 10.6 MJ ME/d, $P<0.01$). The herd with the shortest calving interval (359 days) had the shortest interval to first service (67 days on average) and the highest conception rate to first insemination (66.2%).

Table 3 *Characteristics of herds classified according to their fertility parameters*

	Heat detection rate (%)		Conception rate to 1st AI (%)		Calving interval (days)	
	Low group Mean±s.e.	**High group Mean±s.e.**	**Low group Mean±s.e.**	**High group Mean±s.e.**	**Low group Mean±s.e.**	**High group Mean±s.e.**
No. of herds	6	6	6	6	6	6
Basis of classification	58.7±2.1[a]	84.2±2.8[b]	24.6±1.0[a]	50.8±3.2[b]	383±5[a]	430±5[b]
Cow factors						
PIN value (PIN_{2000})	5.1±2.8	4.9±2.9	7.0±2.8	7.4±2.4	5.8±2.8	9.1±2.2
BCS while dry	3.2±0.1	3.1±0.1	3.3±0.1	3.0±0.1	3.0±0.1[a]	3.3±0.1[b]
BCS loss (0-100 days)	0.6±0.1[a]	0.3±0.1[b]	0.5±0.1	0.4±0.1	0.3±0.1[a]	0.6±0.1[b]
Age at first calving (months)	27.0±0.7	26.8±1.6	24.9±1.1	27.5±1.0	27.0±1.4	26.7±0.8
Dietary factors in first 100 days						
Dry matter intake (kg/cow/day)	20.0±1.2	18.6±0.8	16.6±0.6 [a]	20.4±0.7 [b]	18.2±0.7	19.2±1.3
ME intake (MJ ME/cow/day)	233±12	216±8	195±9[a]	233±6[b]	212±8	222±15
NEB (MJ ME/day)	9.9±1.9[a]	2.6±1.7[b]	7.5±2.4	3.7±2.7	1.8±1.5[a]	10.6±1.7[b]
Other dietary factors						
Concentrate intake (kg/cow/year)	1958±177[a]	1239±211[b]	1257±244	1602±149	1098±203[a]	1885±268[b]
Milk from forage (kg; first 100 d)	2249±244	2762±132	2467±162	2757±111	2838±126	2503±164
% milk from forage (first 100 d)	45.0±5.2	59.5±4.8	59.7±6.2	55.0±2.9	63.0±5.4	53.6±5.5
Production factors						
100-day milk yield (kg)	3502±233	3006±145	2698±176[a]	3346±175[b]	2885±147	3305±313
100-day protein (%)	3.11±0.03	3.10±0.05	3.18±0.03	3.10±0.05	3.13±0.06	3.11±0.03
100-day protein (kg)	108.3±6.5	92.9±3.9	85.5±5.2[a]	103.4±5.3[b]	89.8±3.5	102.1±9.2
100-day BF (%)	3.74±0.03	3.69±0.08	3.69±0.09	3.76±0.04	3.74±0.08	3.76±0.08
100-day BF (kg)	130.3±8.4	110.7±6.7	98.8±6.1[a]	125.1±6.1[b]	107.3±5.5	122.9±10.0
305-day milk yield (kg)	8617±684	6949±437	6311±459[a]	8151±531[b]	6676±452	8234±843
305-day protein (%)	3.23±0.04	3.24±0.05	3.32±0.04	3.22±0.04	3.27±0.06	3.24±0.04
305-day protein (kg)	277.0±19.8[a]	223.6±12.1[b]	208.2±13.9[a]	262.3±17.0[b]	216.7±12.2	264.8±25.5
305-day BF (%)	3.77±0.05	3.78±0.09	3.82±0.08	3.79±0.04	3.81±0.07	3.82±0.09
305-day BF (kg)	322.0±22.7	261.3±17.9	242.8±14.6[a]	307.7±20.5[b]	252.4±15.6	313.8±25.0
Calving pattern						
Autumn calving (%)	46±7	53±10	31±9[a]	55±5[b]	50±10	39±8
Compactness (%)	51±4	61±7	62±6	49±5	62±7	51±7
Fertility factors						
Heat detection rate (%)	**58.7±2.1[a]**	**84.2±2.8[b]**	70.1±5.4	72.0±5.6	82.6±3.7[a]	60.7±3.2[b]
Interval to first recorded AI (d)	91±6	76±3	83±7	82±5	74±2[a]	97±8[b]
60-d non-return rate to 1st AI (%)	55.4±4.9	53.0±7.4	43.9±4.3[a]	67.5±2.9[b]	55.2±7.1	57.0±4.8
Conception rate to first AI (%)	36.2±5.0	41.9±6.2	**24.6±1.0[a]**	**50.8±3.2[b]**	44.6±5.5	33.9±5.3
Calving interval (days)	413±5[a]	386±7[b]	413±8	393±9	**383±5[a]**	**430±5[b]**
Cows removed from herd (%)	33.0±3.9	25.3±1.7	30.3±5.3	26.8±2.0	22.7±2.0[a]	36.8±2.9[b]
Cows removed for infertility (%)	6.4±1.3	7.3±0.9	5.1±0.7	5.6±0.8	8.0±1.4	5.5±0.8
Labour availability						
Labour units/100 cows	1.34±0.16	1.37±0.15	1.27±0.09	1.34±0.14	1.22±0.18	1.23±0.09
Labour units/million litres	1.55±0.12	1.76±0.17	1.82±0.14	1.67±0.20	1.61±0.18	1.58±0.21

[a,b] Within pairs of columns, rows with different superscripts are significantly different (P<0.05)

Heat detection rate by month

The heat detection rates by month across all 19 herds are presented in Figure 6. Heat detection rates were significantly lower in the combined months of August, September and October than in the combined months of November, December and January ($P<0.05$). This was partly attributed to the small number of cows being bred between August and October and the tendency for farmers not to record heats at this time. There was also a tendency for lower heat detection rates in March and April compared to December and January. This may be attributed to farmers putting less emphasis on heat detection at the end of the breeding season in autumn calving herds.

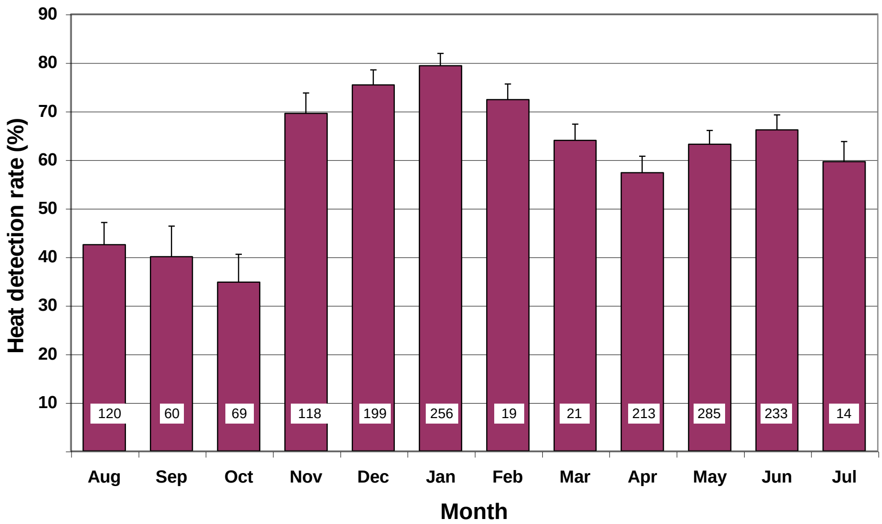


Figure 6 *Heat detection rates in each month for the 19 herds, excluding bull services. The numbers within the bars indicate the number of heats expected*

Conception rate by week postcalving

The conception rate to first insemination increased from weeks 5 to 9 post-calving as shown in Figure 7. Consequently, conception rate was significantly higher in weeks 8 and 9 (38.1 and 38.8%, respectively) than in weeks 5 and 6 (14.3 and 24.5%, respectively; $P<0.01$), and the increase in conception rate from weeks 5 to 16 could be described by the non-linear equation:

$$\text{Conception rate (\%)} = 41.46 - 345 * 0.6^{(\text{week})} \quad (R^2 = 0.91)$$

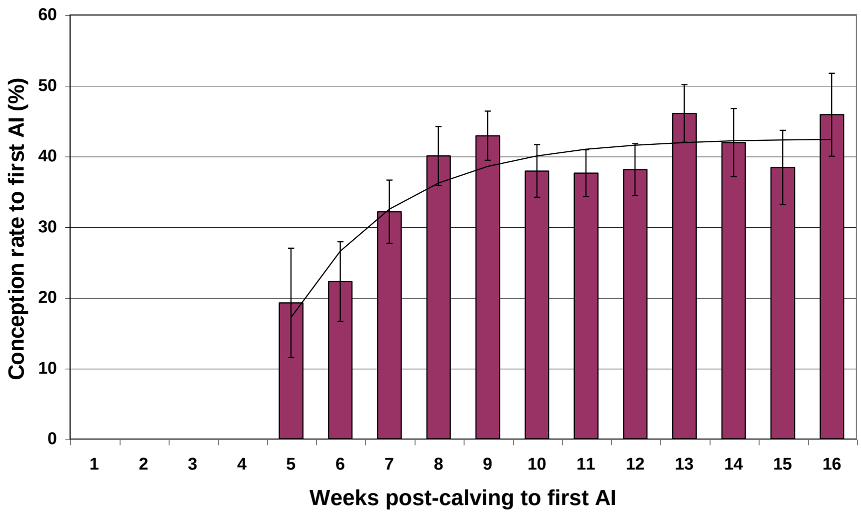


Figure 7 *Calving rate to first AI service in each week after calving across all 19 herds*

Conception rate by month of first insemination

The conception rate by month of first insemination varied between 31.3 and 44.4% as shown in Figure 8. Conception rates were significantly lower in November than in December (35.4 and 45.9%, respectively; P<0.05) and significantly lower in February than in December, January, March and June (33.0% v 45.9, 42.0, 40.4 and 41.2%, respectively; P<0.05). Conception rates in April and May were significantly lower than those in December (37.3 and 34.5% v 45.9%, P<0.05), but not significantly lower than those reported in February or March.

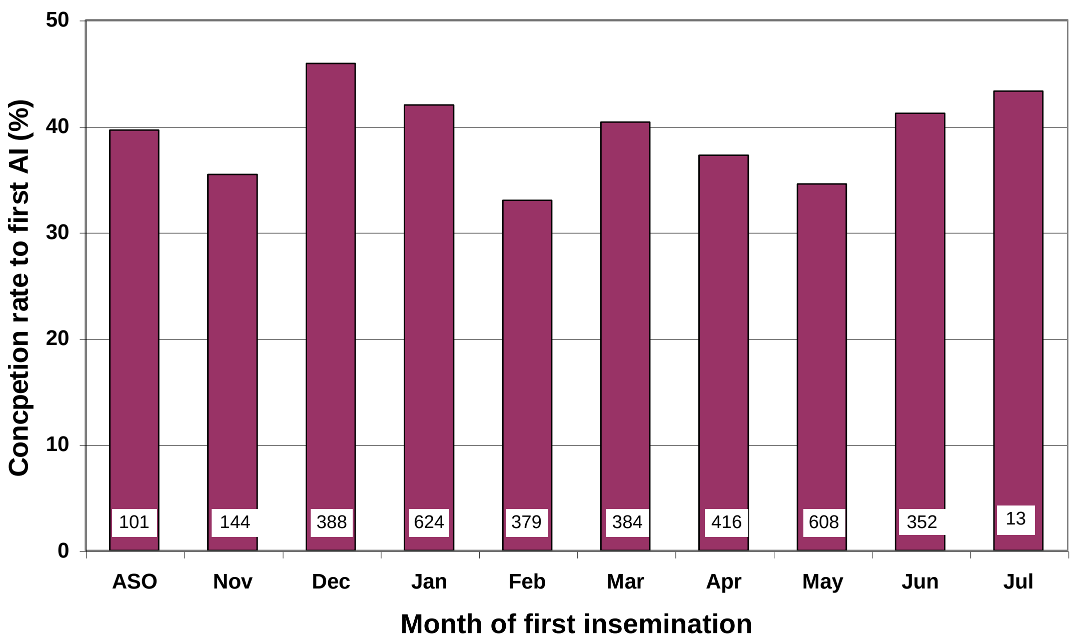


Figure 8 *Conception rate by month of insemination.*

Removal of cows from the herds

Of approximately 2500 cows that calved in each year of the study, 28% were removed, ranging from 17% to 49% between herds, the latter being associated with a herd sale. On average, cows were removed either during or after having completed their third lactation. Of the six general categories describing the reasons for removal, infertility was the principle reason and accounted for 26.8% of removals in year 1 and 27.2% of removals in year 2. However, this varied considerably between herds. Infertility, lameness/locomotion and problems associated with the teats and udder accounted for approximately 50% of all removals as shown in Figure 9.

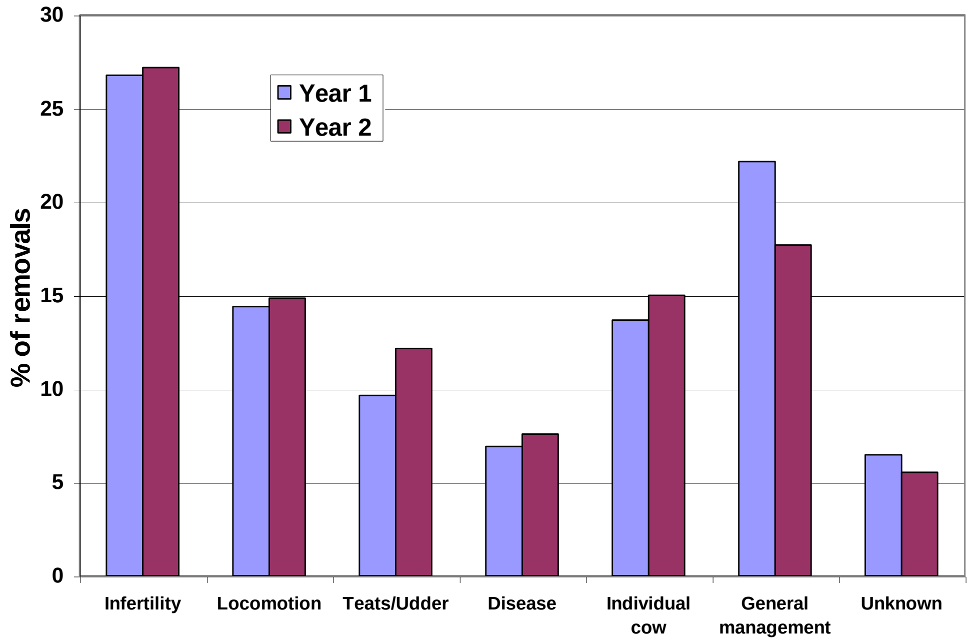


Figure 9 *Reasons for removal of cows from the 19 herds during the two years of the study*

Milk progesterone profiles

Examination of the milk progesterone profiles for individual cows established that the mean interval between successive ovulations was 21.4 days, with no significant difference in the length of the first, second and third post-calving cycles. However, the first post-calving cycle had a higher risk of being short (7-17 days) or long (greater than 25 days) compared to the second post-calving cycle. Furthermore, cows with a short first cycle had a significantly longer interval to commencement of luteal activity than cows with a long first cycle.

Heat detection rate

The heat detection rate varied according to the method of assessment used. When assessed via milk progesterone, the number of heats and services recorded, over the total number of cows likely to be in heat, was estimated to be 39% from calving onwards (herd range 4-57%), while the heat detection rate from day 42 postcalving onwards was 61% (herd range 9-82%). This was more comparable to the heat detection rate estimated via inter- heat intervals of 71% (herd range 53-92%), the large discrepancy being primarily due to many farmers not recording early postcalving heats.

Recording of heats and services

Analysis of milk progesterone profiles indicated that 5.3% of heats (42/786) and 6.2% of services (26/418) were recorded incorrectly. Furthermore, analysis of milk samples taken by the herd-owner at the time of service indicated that 7.4% (166/2258) of services were apparently conducted at the incorrect stage of the oestrus cycle, i.e. when cows had high milk progesterone concentrations, and had little chance of conceiving. Further analysis of the 2258 cows sampled at the time of AI indicated that 4.2% of cows (95/2258) had high milk progesterone concentration and failed to conceive to that service, while 3.1% of cows (71/2258) that had high milk progesterone concentrations conceived to that service, raising the possibility of either sampling error or other possible sources of progesterone.

Interval to commencement of luteal activity

The mean interval to commencement of luteal activity (CLA), indicative of the resumption of oestrous cycles, was 36 days. Overall, 36% of cows had commenced luteal activity by day 20 postcalving and 80% by day 40 postcalving as shown in Table 4. Approximately 12% of cows had not commenced luteal activity by day 50 postcalving. Cows with a longer interval to CLA had a significantly longer interval to first service (Table 4). In addition, as interval to CLA increased, conception rate to first service increased up until day 50 postcalving, after which it fell. However, conception rate to all services did not differ significantly as interval to CLA increased. Overall, as interval to CLA increased, so did calving interval (Table 4).

Cows with an interval to CLA >50 days tended to have higher PIN_{2000} values but similar 100-day or 305-day milk yields compared to cows with shorter intervals to CLA (Table 4). In general, as interval to CLA increased, 100-day milk protein concentration and PIN adjusted protein concentration and condition score in the first 100 days postcalving all decreased. However, over a 305-day lactation, interval to CLA had no significant association with milk yield, milk protein concentration or milk energy output. Increasing interval to CLA was associated with an increased incidence of retained foetal membranes and/or uterine discharge but not with any other health disorders, calving difficulty or SCC parameter. Cows which had an interval to CLA >50 days had a greater risk of being examined or treated for a fertility disorder (P=0.07) during that lactation.

Table 4 *Relationship between interval to commencement of luteal activity (CLA) and fertility parameters, genetic merit (PIN_{2000}), parity, production parameters and condition score (in the first 100 days of lactation)*

Interval to CLA (days)	0-19	20-29	30-39	40-49	50+	SED		Total
Number	336	263	140	78	110			927
Percent	36.2	28.4	15.1	8.4	11.9			100
Interval to first AI (days)	75.5[a]	75.5[a]	77.5[ab]	83.0[b]	95.6	3.4	***	81.4
Interval from CLA to first AI (days)	59.5	50.9	43.5[a]	38.8[ab]	33.9[b]	3.4	***	45.3
Calving interval (days)	393.6[ab]	395.3[ab]	389.4[a]	407.7[bc]	417.8[c]	7.933	**	400.8
PIN_{2000} (£)	6.3[a]	7.5[ab]	4.3[a]	9.0[ab]	11.3[b]	2.1	*	7.7
Parity†	2.7[a]	3.2[bc]	3.5[b]	2.9[ac]	2.5[a]	0.2	***	3.0
100-day milk yield (kg)	2920	2975	2876	2987	2822	67.1	NS	2916
305-day milk yield (kg)	6968	7096	6911	7174	7100	145.5	NS	7050
100-day milk protein (%)	3.16[a]	3.14[ab]	3.12[bc]	3.10[bc]	3.07[c]	0.02	**	3.12
305-day protein (%)	3.27	3.25	3.24	3.22	3.22	0.02	NS	3.24
Condition score (0-100 days)	2.80[a]	2.80[a]	2.74[a]	2.72[a]	2.55[b]	0.05	***	2.72

Within each row, values with different superscripts are significantly different.
NS non-significant, SED standard error of difference, † adjusted for herd only

Atypical progesterone profiles

Atypical progesterone profiles occurred in 41% of cows with 3% of these exhibiting two or more atypical profiles. The incidence of DOVI, DOVII, PCLI and PCLII were 15.6, 11.7, 19.4 and 11.9%, respectively. However, there was a considerable range in incidences of the various atypical patterns between herds, though this can be partially explained by the low number of valid milk progesterone profiles in some herds (range 19-140 profiles per herd). In general, cows with atypical milk progesterone profiles had increased intervals to first service compared to those displaying no atypical profiles as shown in Table 5, consequently leading to an increased calving interval. Conception rates were similar in cows with normal and

Table 5 *Relationship (adjusted for herd and parity) between typical and atypical milk progesterone profiles and fertility parameters, genetic merit (PIN_{2000}), parity, production parameters and condition score (in the first 100 days of lactation)*

	DOVI			DOVII			PCLI			PCLII					
	Typical	Atypical	SED	Typical	Atypical	SED	Typical	Atypical	SED	Typical	Atypical	SED	No atypical patterns	One or more atypical	SED
Number	787	145		560	74		629	151		334	45		549	383	
Incidence (percent)		15.6			11.7			19.4			11.9			41.1	
Interval to first AI service (days)	76.3	91.6	2.7***	74.7	76.3	2.7	74.1	80.5	2.3**	77.0	85.0	3.5*	74.4	85.7	1.9***
Interval from CLA to AI (days)	52.3	35.3	2.9***	49.2	51.9	2.9	46.9	56.1	2.4***	55.7	65.5	3.6**	48.0	51.1	2.0
Calving interval (days)	394.7	410.7	6.2*	392.4	406.6	8.5	391.7	405.7	6.1*	390.2	399.0	9.7	389.8	408.5	4.5***
PIN_{2000} (£)	6.7	10.1	1.6*	6.4	7.4	2.2	6.6	6.6	1.5	5.5	4.7	2.7	7.0	7.7	1.1
Parity†	3.1	2.6	0.2**	2.9	3.5	0.2*	3.0	3.1	0.2	2.9	2.9	0.3	3.0	2.9	0.1
100-d milk yield (litre)	2928	2885	51.7	2970	2949	63.0	2952	3009	47.8	2938	2884	86.9	2907	2937	38.0
305-d milk yield (litre)	7006	7115	114.1	7038	7162	153.6	7017	7160	111.2	6956	7153	212.9	6945	7143	82.0*
100-d milk protein (%)	3.14	3.09	0.02**	3.14	3.12	0.03	3.14	3.13	0.02	3.14	3.12	0.03	3.14	3.11	0.01*
100-d PIN adjusted milk protein (%)	3.14	3.10	0.02*	3.14	3.09	0.03	3.14	3.14	0.02	3.14	3.12	0.03	3.14	3.11	0.01
305-d protein (%)	3.26	3.22	0.02	3.26	3.25	0.02	3.25	3.25	0.02	3.26	3.23	0.03	3.26	3.24	0.01
100-d milk energy output (GJ/cow)	8.76	8.54	0.15	8.90	8.76	0.19	8.83	8.98	0.14	8.82	8.74	0.26	8.69	8.74	0.11
305-d milk energy output (GJ/cow)	21.52	21.81	0.359	21.60	21.85	0.45	21.48	22.00	0.33	21.34	22.05	0.61	21.31	21.94	0.25*
Condition score (0-100 days)	2.79	2.58	0.04***	2.79	2.66	0.05**	2.78	2.77	0.04	2.80	2.80	0.07	2.79	2.68	0.03***

DOVI delayed ovulation type I, DOVII delayed ovulation type II, PCLI persistent corpus luteum type I, PCLII persistent corpus luteum type II
AI, artificial insemination, CLA commencement of luteal activity, SED standard error of difference, † adjusted for herd only.

atypical progesterone profiles, with the exception of cows displaying a DOVII profile, where conception rates were significantly lower. Individual atypical profile types did not appear to affect culling or culling for infertility rates, although cows with one or more atypical profiles were significantly more at risk of being culled than those with no atypical profile.

Cows with one or more atypical profiles had significantly lower 100-day milk protein concentration and condition score in the first 100 days of lactation but higher 305-day milk yield and milk energy output compared to cows displaying no atypical profiles as shown in Table 5. Additionally, cows displaying an atypical DOVI profile had higher PIN_{2000} values, were of lower parity, had a lower 100-day milk protein concentration and a lower condition score in the first 100 days of lactation than cows displaying no atypical DOVI profiles (Table 5). Cows displaying an atypical DOVII profile had a lower condition score in the first 100 days of lactation compared to cows displaying no atypical DOVII profiles (Table 5). Atypical PCLI and PCLII profiles did not appear to be associated with significant alterations in genetic or production parameters (Table 5).

The relationship between atypical progesterone profiles and assistance at calving, incidence of retained foetal membranes and somatic cell count was examined. Cows with an atypical DOVI profile were more likely to have been examined and/or treated for a fertility disorder compared to cows with no atypical DOV1 profile. Cows with retained foetal membranes and/or uterine discharge and post-calving disease had a higher risk of developing prolonged corpora lutea (both PCLI and PCLII-type progesterone profiles). There was no difference in risk of other calving and health parameters between atypical and typical profile groups.

3. Management strategies to help improve reproductive performance

Three intervention programmes were launched in autumn 2001 for farmers currently involved in the study. All three programmes are currently on-going and are described briefly as follows:

a) <u>Data management intervention – 6 participating herds</u>:

Response to this program has been well received by those involved, who regularly send in their faxed reports three days per week and in return receive an output similar to that shown in Figure 10. While historical data from the first two years of herd monitoring have been processed via the same program at the same calendar date each year, it is too early to report on the effects of this intervention program on herd reproductive performance. However, brief findings from the four herds concerned are presented in Table 6.

Farmer's name
Address 1
Address 2

Fax No.

AgriSearch NI
Farmer Funded Research

Herd update: 29-Mar-02
Voluntary waiting period: 42 days
Start Date of Breeding Season: 01-Dec-01

Action List:

1. Cows ready for service within the next 4 days

60 109 149 171

2. Cows which may repeat within the next 4 days

66 110 156 175 111

Warning List:

1. Cows with no previous heat or service recorded (greater than 60 days calved)

43 136 178

2. Cows with no previous heat or service recorded (42-60 days calved)

2 6 48 80 129 133 204 209 250 251
278 325

3. Cows with three or more services to date

20 94 182 215 220

4. Cows with missed heat or unusual cycle length

100 141 225

Reminder List:

1. Cows calved less than your voluntary waiting period (and not ready for service)

7 27 28 30 36 38 40 55 106 169
198 203 211 245 265 268 276

2. Cows more than 6 weeks since last AI (consider for pregnancy diagnosis)

72 85 98 99 102 94 95 100 101 103
107 113 116 252 257 258 260 266 267 269
272

3. Cows with negative pregnancy test

33 160 162 176 225

Progress Monitor:

	Current	3 Weeks Ago	Overall	
Submission Rate (%)	36(22)	46(24)	46(157)	(number in brackets is number of animal events)
60 Day Non-Return Rate (%)	45(38)	69(13)	50(50)	(NRR overestimates calving rate by 15% on average)

Figure 10 *Example output from data management intervention program*

Table 6 *Number of events recorded and outputs from the progress monitor for 4 herds at a fixed calendar date for three years, two years with no feedback (years 1 and 2) and one with feedback (monitor)*

		Year 1	Year 2	Monitor
Calvings				
Herd	A	125	161	189
	B	112	107	97
	C	76	101	86
	D	126	161	160
Start of breeding season				
Herd	A	20 Nov	24 Nov	18 Nov
	B	1 Oct	15 Nov	1 Nov
	C	1 Jan	1 Dec	25 Nov
	D	14 Dec	14 Dec	9 Nov
Services				
Herd	A	77	146	142
	B	95	86	87
	C	35	130	65
	D	133	119	158
Interval to first service (days)				
Herd	A	87	86	90
	B	123	93	99
	C	85	76	87
	D	102	85	89
Submission rate to first service (%)				
Herd	A	31	41	**45**
	B	26	35	32
	C	36	58	**61**
	D	57	38	53
60-day non-return rate (%)				
Herd	A	58	44	56
	B	52	59	68
	C	-	42	67
	D	55	86	57

Figures highlighted in bold may be indicative of improved performance through this intervention

b) Nutritional intervention – 2 participating herds:

Preliminary findings of this study indicate that feeding of a high energy supplement in early lactation increased milk yields by approximately 1.5 litres per day, but the high fat level of the supplement appears to have depressed milk butterfat content. While no estimate of reproductive performance has been established as yet, cows fed the supplement have been reported to show stronger heats, which may be as a consequence of reduced negative energy balance in early lactation.

c) A.I. technique – 6 participating herds:

At the time of writing approximately 800 inseminations have taken place on the 6 farms, 400 via DIY-AI and 400 via AI-Services. As yet, it is too early to establish the conception rate to insemination by the two methods.

DISCUSSION

This study has examined dairy cow fertility in Northern Ireland, both in herds with acute infertility problems, and in 19 normal commercial dairy (monitor) herds where herd fertility was examined over a two-year period.

In the herds with acute infertility problems, there was no apparent single predominant cause of infertility though inadequate nutrition was suspected as being a contributor to the problem in five of the ten herds. Ineffective herd management techniques such as poor heat detection and poor AI technique contributed to infertility in some herds while lack of regard to hygiene, both at calving and insemination led to disease and may have contributed to the low levels of fertility in others.

In the study of the 19 monitor herds, overall reproductive performance was assessed by determining heat detection rate, conception rate and calving interval, with all three parameters varying considerably both from herd to herd and year to year within a particular herd. Heat detection rate, based on inter-heat and inter-service intervals, was good with an estimated 71% of cows being detected in heat, but this varied from 53% to 92% between herds. The best rates were observed in herds where frequent observations of cows were made during the breeding period (up to 5 times per day and 20 minutes per observation period, especially late at night), with subtle changes in cow behaviour also being noted, not just standing to be mounted. While the overall estimate of heat detection rate of 71% was higher than other previously reported estimates using the same method, assessment of heat detection rates from the progesterone profiles produced much lower values. Indeed, using this method heat detection rate was estimated to be 39% when evaluated from calving onwards, or 61% when evaluated from the start of the breeding season.

In each year of the study, the average conception rate to first service was less than 40% and comparable to recent findings from the USA and Great Britain. While some seasonal variation did occur, there was no evidence of a decline in conception rates following turnout of cows in the spring, with conception rates in April and May being similar to those in February. Indeed, there was much variation between herds, and between years within the same herd. This may reflect differences in heat detection procedures, insemination technique or other management changes between years. These issues are currently being addressed in the intervention studies. For example, the effect of insemination technique on conception rate is currently being examined in a study where the farmer and a professionally trained AI technician are conducting inseminations on an alternate-day basis. Indeed, a recent similar study in Australia has indicated that, on average, conception rates to DIY services are 3% lower than those conducted by a professional inseminator. The data management intervention study will also enable assessment of the accuracy of heat detection within and between herds.

Results from the study of 19 commercial herds indicates that nutrition of the cow is an important factor determining reproductive performance of the herd, particularly through effects on body condition at calving and body condition loss in the postcalving period. When herds were grouped according to their average calving interval, herds with longer calving intervals had fatter cows at calving and these cows had greater condition loss in the postcalving period than cows in herds with shorter calving intervals (see Table 3). The highest conception rates to first service were observed in herds where cows were not too fat at calving (i.e. less than body condition score 3.0) and body condition loss was controlled by maintaining high dry matter intakes after calving, thereby limiting the degree of negative energy balance in the postcalving period.

While various reports have suggested that declining fertility in dairy cows is associated with increased genetic merit for milk production and an increased percentage of Holstein genes, findings of the present study indicate no such relationship at a herd level. However, further investigation is necessary to establish if there are any within herd effects. Herds with higher conception rates were higher yielding. Cows in these herds were in moderate condition at calving and had higher postcalving ME intakes. However, these effects may be confounded by a predominance of compact autumn-calving herds and high quality winter rations. In contrast, herds with low conception rates tended to have fewer autumn-calving cows and more spread calving patterns.

Analysis of progesterone profiles in this study has established that the modern Holstein-Friesian dairy cow has a longer interval to the commencement of luteal activity and a higher incidence of atypical progesterone profiles than previously reported. In general, prolonged intervals to the commencement of luteal activity and atypical progesterone profiles were associated with indicators of nutritional stress, poorer production in early lactation and postparturient disease, particularly retained foetal membranes. This was manifested in prolonged intervals to first insemination and ultimately prolonged calving intervals. Indeed, across all cows, the average interval to first service was extremely long at 85 days, giving most cows little opportunity to calve again within 365 days. In this study calving interval varied considerably from herd to herd, and this reflected the diverse range of management systems.

Calving interval is a crude assessment of reproductive performance as it does not take account of cows removed from the herd. The proportion of cows removed varied considerably from herd to herd, and if included, those cows removed for infertility would extend the average calving interval of the herd considerably. Indeed, reappearance rate has recently been used to assess the reproductive performance of suckler cows on Northern Ireland farms and may also be applied to dairy cows as shown in Figure 11. In this study, only 23% of the 2500 cows that calved, calved again within 365 days and only 43% calved again within 400 days. Almost 30% of cows had no subsequent calving, being removed from the herds for various reasons. While reappearance rate is useful for the historical assessment of reproductive performance, Australian researchers have devised a similar measure for assessing reproductive performance in the short-term, viz., in-calf rate, which takes account of interval to first service and heat detection rate in cows intended for breeding. This index only excludes those cows intended for culling or for sale prior to the start of the breeding period. In seasonal-block calving herds with a defined start-date for the breed season, it is appropriate to use the 6-week in-calf rate, i.e. the percentage of cows in-calf within 6 weeks of the start of the breeding season. In herds with a prolonged calving period, as occurs in the majority of Northern Ireland herds, it is more appropriate to use the 100-day in-calf rate, i.e. the percentage of cows in-calf within 100 days of calving.

The average 100-day in-calf rate in this study was 32.4% with a wide variation between the 19 monitor herds as shown in Figure 12, demonstrating the variation in reproductive performance between farms. The 100-day in-calf rate also highlights differences in farm management practices, for example, the non-service of cows with high levels of production for a prolonged period. However, there is no evidence that delaying service in these cows will increase conception rate. Indeed, it is possible to achieve a 100-day in-calf rate of greater than 40% and a 200-day not-in-calf rate of less than 20% in the dairy herds with the best reproductive performance. In the future these should be realistic targets for all dairy herds in Northern Ireland.

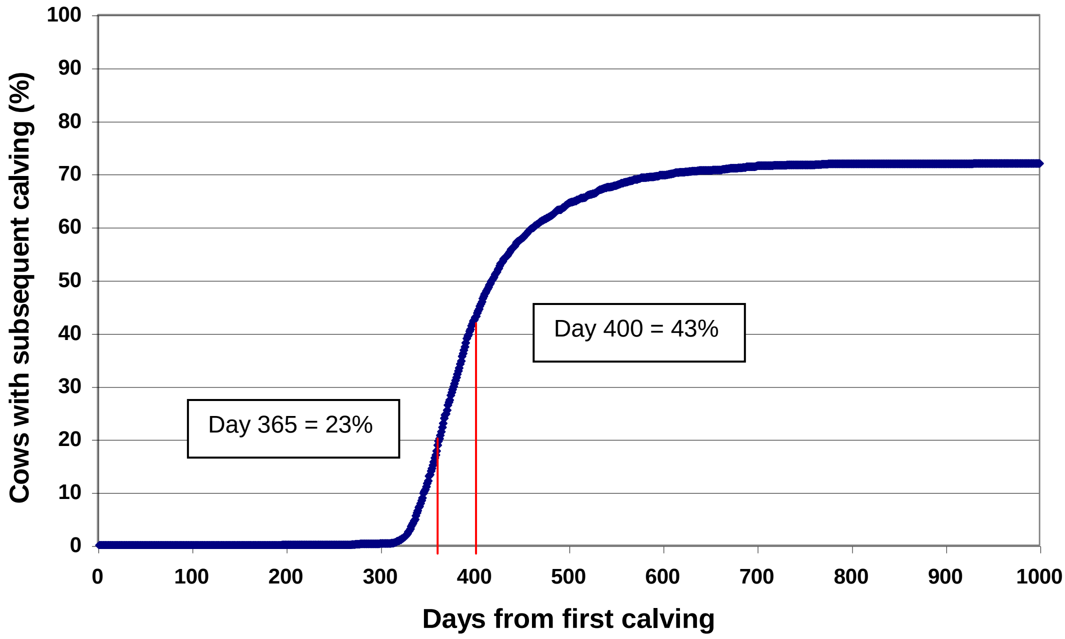
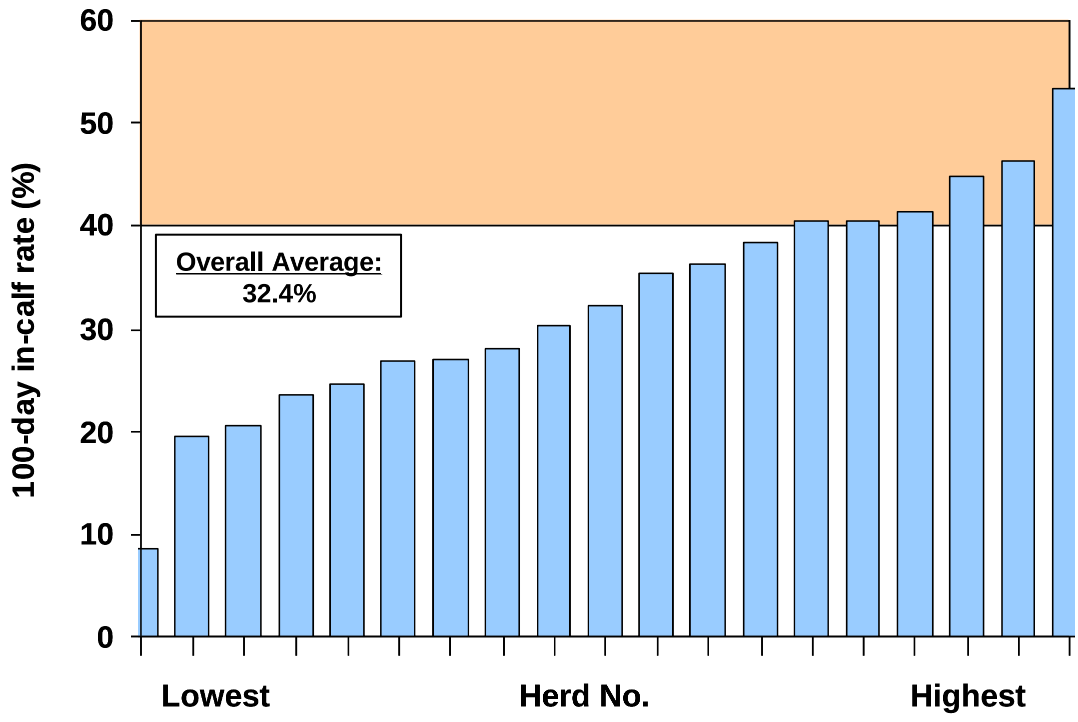


Figure 11 *Reappearance rate after calving in all cows across the 19 herds*

a) 100-day in-calf rate



b) 200-day not-in-calf rate

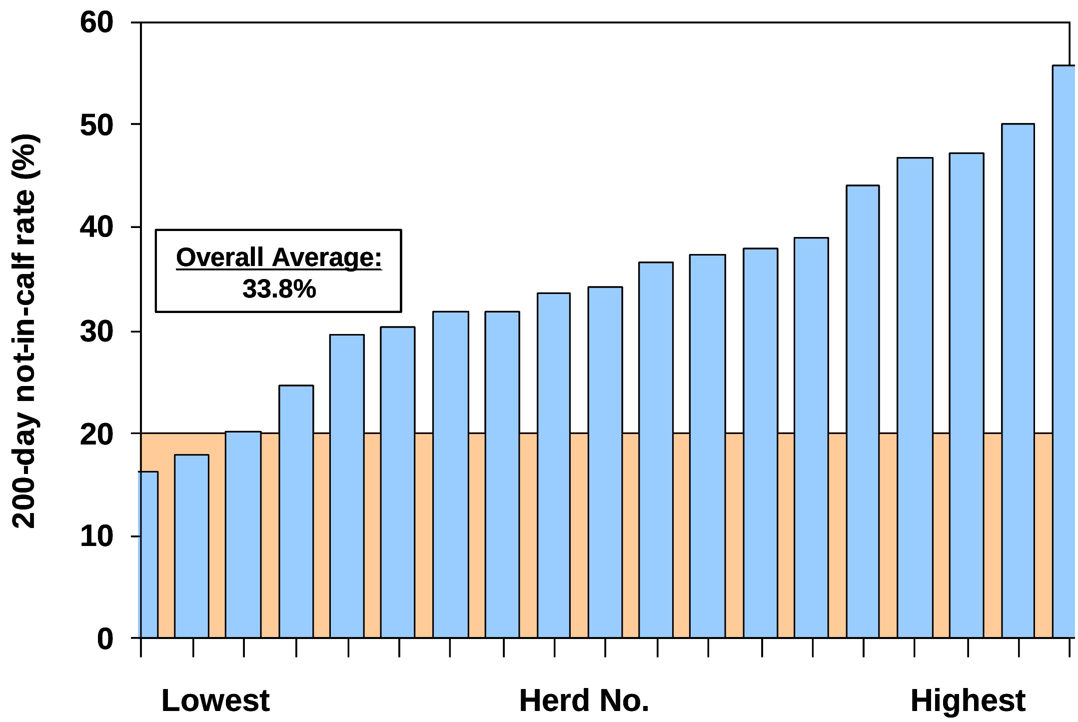


Figure 12 *Alternative measures for the assessment of reproductive performance, 100-day in-calf rate and 200-day not-in-calf rate (shaded areas indicate targets)*

CONCLUSIONS

A detailed investigation of 10 herds with acute infertility problems suggested that there is no apparent single predominant cause of infertility in Northern Ireland dairy herds. While inadequate nutrition and ineffective herd management techniques such as poor heat detection and poor AI technique may have contributed to infertility in some herds, in others herds it arose through disease attributed to lack of hygiene at calving and insemination. The various factors, presumed to have contributed to acute infertility, indicate that early investigation is essential and that a full investigation of all potential causes is required.

In the study of 19 commercial herds, overall reproductive performance was disappointing, indicating that infertility is a major problem in many Northern Ireland dairy herds. Analysis of milk progesterone samples confirmed that cows now take longer to resume ovarian activity postcalving and that the incidence of atypical progesterone profiles has increased. While the overall conception rate to first service of 38.7% is low, and comparable with other recently published estimates, this study has highlighted that there is wide variation between herds. Body condition of cows at calving and the control of body condition loss in the postcalving period are important determinants of reproductive performance, with excessive body condition loss and negative energy balance in the postcalving period being associated with higher incidences of atypical progesterone profiles. However, other factors such as management and season also contribute to differences in reproductive performance between herds. At a herd level, genetic merit did not have a negative relationship with reproductive performance. This indicates that herds with high genetic merit cows can achieve acceptable levels of fertility if good heat detection is practised, cows calve in moderate body condition, and body condition loss in the postcalving period is minimised.

A key recommendation from this research programme is that in-calf rate (6-week in calf rate for block calving herds and 100-day in-calf rate for spread calving herds) is adopted as a more appropriate and meaningful measure of overall herd fertility than calving interval. In-calf rate incorporates both submission rate and conception rate, highlighting the opportunity to compensate for lower conception rate by increasing submission rate. The target 100-day in-calf rate for Northern Ireland should be greater than 40%. This can be achieved primarily by improving submission rate through reducing the proportion of anoestrous cows in early lactation, improving heat detection rate and serving cows much earlier after calving.

ACKNOWLEDGEMENTS

The valuable contribution and hard work of all the farmers involved in this study is gratefully acknowledged – Messrs Robin and George Bingham, Antrim; Mr William Cromie, Banbridge; Mr Harpur Doupe, Caledon; Mr David Eldon, Portadown, Messrs Ronnie and Roderick Farrell, Lisnaskea; Mr Pat Fullerton, Tobermore; Mr Ken Gill, Ardglass; Messrs John and John Graham, Broughshane; Messrs Jackie and Stephen Hamilton, Armagh; Mr Gerard Maguire, Lisnaskea; Mr Brian Mawhinney, Doagh; Mr Denis Minford, Crumlin; Montgomery Bros, Eglinton; Messrs John and Jason Rankin, Newtownards; Messrs Will and Gareth Taylor, Kirkcubbin; Mr David Throne, Bready; Mr Albert Wallace, Tobermore; Messrs John and Jay Warden, Bangor; Dr Raymond Hunter, Dungannon.

The authors also gratefully acknowledge the following:

- Research and technical staff of the Agricultural Research Institute of Northern Ireland, Biometrics Division, Veterinary Sciences Division and Agricultural and Environmental Sciences Division
- Veterinary surgeons from throughout Northern Ireland who assisted in blood sampling on monitor farms
- Provision of funding by AgriSearch and the Department of Agriculture and Rural Development.

PRESENTATIONS AND PUBLICATIONS

Mayne, C.S. (2001). Management Opportunities to Improve Dairy Herd Fertility. *Paper presented to Ulster Grassland Society, Greenmount College, February 2001.*

Mayne, C.S., Mackey, D.R. and Verner, M. (2002). Dairy herd fertility – latest developments. *Proceedings of the Dairy Research Seminar, Agricultural Research Institute of Northern Ireland, March 2002.*

Mayne, C.S., Verner, M., McCaughey, W.J., McCoy, M.A., Lennox, S.D., Catney, D.C., Kennedy, B.W. and Gordon, F.J. (2001). An investigation of the key factors influencing reproductive performance in dairy herds in Northern Ireland. *Proceedings of the British Society of Animal Science Occasional Meeting, Fertility in the High-Producing Dairy Cow.* Corrib Great Southern Hotel, Galway, Ireland, 20-22 September, 1999, p.43, and *British Society of Animal Science Occasional Publication No. 26,Vol. 2, Fertility in the High-Producing Dairy Cow*, pp.323-329.

Mayne, C.S., McCoy, M.A., Lennox, S.D., Mackey, D.R., Verner, M., Catney, D.C., McCaughey, W.J., Wylie, A.R.G., Kennedy, B.W. and Gordon, F.J. (2002). An Investigation of Fertility Performance in Dairy Herds in Northern Ireland. *Veterinary Record (In Press).*

McCaughey, W.J., McCoy, M.A., Mayne, C.S., Verner, M., Lennox, S.D., Catney, D.C., Kennedy, B.W. and Gordon, F.J. (2001). Investigation of infertility problems in dairy herds. *Proceedings of the British Society of Animal Science Occasional Meeting, Fertility in the High-Producing Dairy Cow.* Corrib Great Southern Hotel, Galway, Ireland, 20-22 September, 1999, p.90, and *British Society of Animal Science Occasional Publication No. 26,Vol. 2, Fertility in the High-Producing Dairy Cow*, pp.485-489.

McCoy, M.A., Lennox, S.D., Mayne, C.S., McCaughey, W.J., Verner, M., Catney, D.C., Kennedy, B.W. and Gordon, F.J. (2001). An investigation into the relationship between milk progesterone concentrations in fore-milk and composite milk samples. *Proceedings of the British Society of Animal Science Occasional Meeting, Fertility in* *the High-Producing Dairy Cow.* Corrib Great Southern Hotel, Galway, Ireland, 20-22 September, 1999, p.84, and *British Society of Animal Science Occasional Publication No. 26,Vol. 2, Fertility in the High-Producing Dairy Cow,* pp.471-473.

McCoy, M.A., Lennox, S.D., Mayne, C.S., McCaughey, W.J., Verner, M., Catney, D.C., Wylie, A.R.G., Kennedy, B. and Gordon, F.J. (2000). Dairy herd fertility. *Proceedings of the Ruminant Research Seminar, Agricultural Research Institute of Northern Ireland, May 2000.*

McCoy, M.A., Lennox, S.D., Mayne, C.S., McCaughey, W.J., Verner, M., Mackey, D.R., Catney, D.C., Wylie, A.R.G., Kennedy, B.W. and Gordon, F.J. (2001). Dairy Herd Fertility Study - Results from Year 1. *Northern Ireland Veterinary Today, Autumn 2001. pp.62-65.*

McCoy, M.A., Mayne, C.S., Lennox, S.D., Verner, M., Mackey, D.R., McCaughey, W.J., Catney, D.C., Kennedy, B.W., Wylie, A.R.G. and Gordon, F.J. (2001). Reproductive performance in dairy herds in Northern Ireland. *Proceedings of the Association of Veterinary Teachers and Research Workers (Irish Region) Spring Meeting. Abstract to be published in Irish Veterinary Journal.*

McCoy, M.A., Lennox, S.D., Mayne, C.S., McCaughey, W.J., Edgar, H.W.J., Catney, D.C., Verner, M., Mackey, D.R. and Gordon, A.W. (2002). Milk progesterone profiles and their relationship with fertility, production and disease in dairy cows in Northern Ireland. *Animal Science (Submitted).*

McCoy, M.A., Mayne, C.S., Lennox, S.D., Verner, M., Mackey, D.R., McCaughey, W.J., Catney, D.C., Gordon, A.W., Kennedy, B., Wylie, A.R.G. and Gordon, F.J. (2002). Fertility and milk progesterone profiles in dairy herds in Northern Ireland. *AVTRW Current Topics in Veterinary Science 56th Annual Conference, Scarborough, March 2002 and Research in Veterinary Science* **72 (Suppl. A):**9.