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and protein production. While the magnitude of the changes differed across the studies, a function of the different production levels of the cows in these studies, the change in protein production as a fraction of the change in milk production was in close agreement among the studies. The values (as a percentage) were 4.0 in the present study compared to 3.7 (Aleandri *et al.*, 1990) and 3.0 (Bovenhuis *et al.*, 1992). Analogous figures for fat production were 4.7, 2.9 and 2.3, respectively. While these changes were not as in close agreement as for protein production the results still indicate a similar effect of protein phenotype across the studies.

The benefits of including protein phenotype in the breeding objective depends on its value as from a processing perspective and its association with traits of economic importance. While β-LG BB milk was found to have beneficial aspects from a processing perspective, the results in this study indicate that total protein production from BB cows would be lower than that of AA cows, thus partially negating the value of this phenotype. Such issues must be taken into account when determining the net value of the different milk protein phenotypes.

The present work is a first study to examine the associations between milk protein phenotype and production traits in New Zealand dairy cattle. Future work will investigate the relationships between protein phenotype and nonproduction traits such as reproductive performance, somatic cell count and conformation. The measure of protein yield considered in this study did not differentiate between casein and whey proteins. In order to properly assess the value of milk of a specific milk protein genetic variant composition for a given manufactured product it will be necessary to determine the association of protein phenotype with casein and whey production. Finally, in the case of the casein proteins, it will be necessary to establish whether the effect on production is due to the genetic variants themselves or to linked alleles. Given a situation of linkage, the success of a breeding programme aimed at changing the frequencies will be influenced by the closeness of the linkage.

REFERENCES

Aleandri, R., Buttazzoni, L.G. and Schneider, J.C. 1990. The effects of milk protein polymorphisms on milk components and cheese-producing ability. *Journal of Dairy Science* **73:**241-255.

Bovenhuis, H., van Arendonk, J.A.M. and Korver, S. 1992. Associations between milk protein polymorphisms and milk protein traits. *Journal of Dairy Science* **75:**2549-2559.

Geldermann, H. 1995. Aspects of genetic variants in dairy cattle breeding. In Implications of Genetic Polymorphism of Milk Proteins on Production and Processing of Milk. *International Dairy Federation* **304:** 22-22.

Groeneveld, E., Kovac, M., and Wang, T. 1990. PEST, a general purpose BLUP package for multivariate prediction and estimation. In *Proceedings of the 4th World Congress on Genetics Applied to Livestock Production*, **13:**488-491.

Hill, J.P., Paterson, G.R., Lowe, R. and Johnston, K.A. 1995. Effect of (-lactoglobulin variants on curd firming rate, yield, maturation and sensory properties of Cheddar cheese. In Implications of Genetic Polymorphism of Milk Proteins on Production and Processing of Milk. *International Dairy Federation* **304:**18-19.

Jakob, E. 1995. Effect of genetic polymorphism on milk protein composition. In Implications of Genetic Polymorphism of Milk Proteins on Production and Processing of Milk. *International Dairy Federation* **304:**7-8.

Ng-Kwai-Hang, K.F. and Grosclaude, F. 1992. Genetic polymorphism of milk proteins. In Advanced Dairy Chemistry - 1: Proteins (Ed. Fox P F) Elsevier Science Publishers Ltd, London, pp 405-455.

Assessment of female traits for genetic improvement of fertility in dairy cattle

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ABSTRACT

The objective of the present study was to investigate the suitability of various fertility traits for describing the reproductive performance of dairy cows in New Zealand. Using a data set from herds participating in the Livestock Improvement Sire Proving Scheme over the 1986/87 to 1992/93 seasons, the following female fertility traits have been investigated. Based on the start of mating (STOM) in a particular herd, the intervals from STOM to first mating (SMFM) and to the successful mating (SMCO) were calculated and compared to the internationally used traits that are based on the calving date, such as, calving to first mating (CFM) and calving to successful mating (days open, DO). Further traits considered are age at calving (AC), number of matings per conception (NS), first to successful mating (FMCO), calving interval (CI) and two traits that indicate whether a cow became pregnant within 21 or 42 days of STOM (PR21, PR42). The traits defined for the unique conditions in New Zealand, SMFM, SMCO, PR21 and PR42 emphasize the economic importance of reproduction to dairy production. The comparison to overseas studies using DO, FMCO and CI showed that New Zealand dairy cows had a better fertility performance than overseas cows.

INTRODUCTION

With the seasonal nature of dairy production in New Zealand, reproductive performance, or fertility, is a key determinant of production efficiency and genetic gain. However, up till now there has been no deliberate selection for female fertility traits in New Zealand. Overseas results have shown sufficient genetic variation in fertility traits to allow for selection for fertility (Philippson, 1981). However, due to the unique features of seasonal production in New Zealand, these overseas results may not be directly applicable to the New Zealand situations.

Female fertility traits for New Zealand dairy cows have been investigated by Macmillan (1987, 1995) and Xu (1995). However, the number of observations involved in these studies was very limited and can not be regarded as representative for the whole population of dairy cows in New Zealand. In the current research a large data set from Sire Proving Scheme herds throughout the whole country was analysed. Different fertility traits that account for the unique production conditions in New Zealand have been determined and compared to overseas results. In this paper means and frequency distributions for the fertility traits are presented. In the companion paper (Grosshans *et al.*, 1996) we report the genetic parameters for the fertility traits of New Zealand dairy cows.

MATERIALS AND METHODS

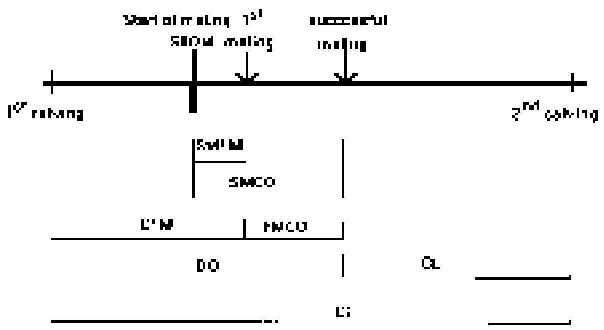
Reproductive performance records of 86069 cows from Sire Proving Scheme herds that calved for the first time between the seasons 1986/87 and 1992/93 were extracted from the national dairy animal database. Only animals born to Livestock Improvement sires were considered. Records were removed from the original data set if there were no mating dates for the first lactation, if sires had less than 5 daughters or if there were less than 10 useable records per herd. This resulted in 66294 daughter records of 1077 sires available for the first and 56923 records for the second lactation, respectively.

The investigated fertility traits are graphically presented in Figure 1. Under New Zealand conditions, the major concern for the farmer is to have as many cows in calf as possible after the start of mating regardless of the number of days after calving. The traits SMFM (start of mating to first mating) and SMCO (start of mating to conception) account for this fact. SMFM characterises the ability of a cow to show oestrus after the start of mating. The ability for a cow to conceive after the first mating is further looked at by using the interval between the first and the successful mating (FMCO). SMCO is a combined trait composed of SMFM and FMCO.

These traits are compared to the interval traits, calving to first (CFM) or successful mating (days open, DO), which are widely used overseas. Further traits are age at calving (AC), number of services (NS, both artificial and natural matings), calving interval (CI) and PR21 and PR42. PR21 or PR42 stand for the percentage of pregnant cows at day 21 or 42 of the mating period. The last two traits are used as alternatives to the interval traits. Because of the seasonality it is crucial for NZ farmers to have as many cows pregnant during the first 21 or 42 days of AI.

The statistics were calculated using the SAS programme package (SAS Institute Inc., 1989). Due to the large number of observations, tests of significance were not possible and most of the differences were assumed statistically different because of the large number of animals involved.

FIGURE 1: Graphical representation of the interval fertility traits investigated in the current study. (SMFM: Interval from start of mating (STOM) to first mating; SMCO: Interval from STOM to successful mating; CFM: Interval from calving to subsequent first mating; FMCO: Interval from first to second mating; DO: Interval from calving to successful mating; CI: Interval between consecutive calvings; GL: Gestation length).



RESULTS

Means and standard deviation of the fertility traits for the first and second lactations are presented in Table 1. The cows were on average 732.0 ± 22.6 days old at first and 1105.8 ± 23.4 days old at second calving. Means for SMFM and SMCO in the first lactation were 17.5 and 31.7 days, respectively. In the second lactation, SMFM was .5 days and SMCO .9 days earlier than in the first lactation. The first mating was carried out on average 84.8 days after calving. The interval between the first and successful mating was 14.2 days. The average value for DO was 99.0 days and for CI 374.5 days in the first lactation. In the second lactation, DO and CI were 10.6 and 9.3 days, respectively, shorter than in the first lactation. For a successful conception, 1.50 and 1.49 matings were needed in

TABLE 1: Means and standard deviations (s) for the fertility traits .

		1st lactation			2nd lactation		
Trait[a)]		n[b)]	$\bar{x}$	s	n	$\bar{x}$	s
SMFM	d	66294	17.5	18.7	56923	17.0	19.5
SMCO	d	66294	31.7	30.6	56923	30.8	30.3
CFM	d	66294	84.8	22.0	56923	75.0	20.7
FMCO	d	66294	14.2	25.6	56923	13.4	24.3
DO	d	66294	99.0	32.0	56923	88.4	29.8
CI	d	58449	374.5	25.8	48573	365.2	24.1
AC	d	66294	732.0	22.6	56923	1105.8	23.4
NS		66294	1.50	0.74	56923	1.49	.73
PR21		66294	0.48	0.50	56923	.50	.50
PR42		66294	0.75	0.43	56923	.76	.42

a) Traits: SMFM: Interval from start of mating (STOM) to first mating; SMCO: Interval from STOM to successful mating; CFM: Interval from calving to subsequent first mating; FMCO: Interval from first to successful mating; DO: Interval from calving to successful mating; CI: Interval between consecutive calvings; AC: Age at calving; NS: Number of service (artificial and natural matings) per conception; PR21, PR42: Proportion of cows pregnant within 21 (PR21) or 42 days (PR42) after STOM

b) n: Number of observations

the first and second lactation, respectively. The percentage of cows that got pregnant within the first 21 or 42 days after start of mating increased from 48% and 75%, respectively in the first lactation to 50% and 76% in the second lactation.

The frequency distribution for SMFM and SMCO in the first lactation are shown in Figure 2 and Figure 3. CFM and DO are nearly normally distributed around their mean and therefore are not presented here. Figure 2 demonstrates that the majority of first matings were carried out within the first 21 days after the STOM. A unique feature for this distribution was that 5.6% of all first matings (3698 cows) were carried out exactly on the date of the start of mating. Consequently there was more cows conceived on day 0 than on any other days. After day 22 from the STOM, the total number of cows mated and conceived each day decreased (Figure 3).

Means and standard deviations for pure (>14/16) Friesian and Jersey cows are presented in Table 2. Jerseys had a shorter time interval from start of mating or calving to first mating than Friesians. The difference was 3.5 days and 5.4 days for SMFM and 4.9 days and 2.9 days for CFM in the first and second lactation, respectively. The number of matings per conception (NS) was 1.51 than 1.52 for Jerseys and slightly higher than for Friesian at 1.49 and 1.48 in the first and second lactation, respectively. FMCO of Jersey cows in the first and second lactation was .2 and .6 days longer than that of Friesians. The shorter interval between calving and first mating for Jersey as compared to Friesian cows contributed to a shorter DO and CI. The differences between Jersey and Friesian cows in DO and CI decreased in the second lactation (2.3 and 0.9 days respectively) compared to the first lactation (4.7 and 3.3 days).

FIGURE 2: Distribution of the interval from start of mating to first mating (SMFM).

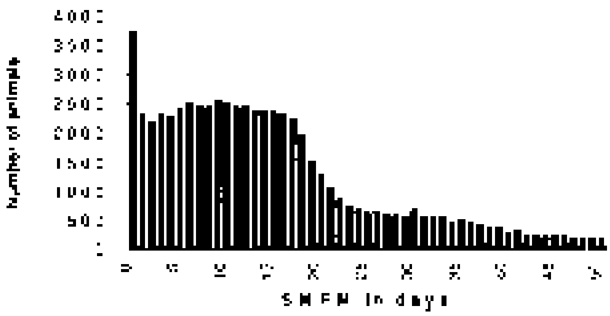
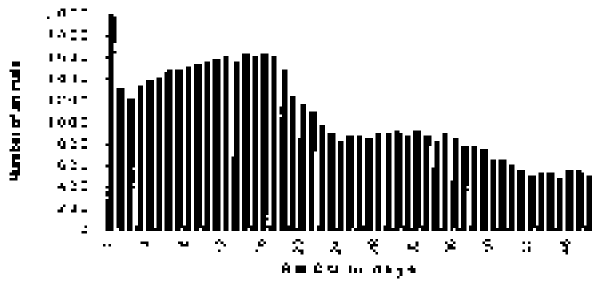


FIGURE 3: Distribution of the interval from start of mating to successful mating (SMCO).



DISCUSSION

The seasonal production conditions in New Zealand have resulted in a younger age at calving and a shorter calving interval compared to overseas results. Means for calving interval are reported to be 380 and 394 days for Jersey (Hansen, 1978 and Silva *et al.* 1992) and between 382.4 to 396 days for Holstein Friesian (Hansen, 1978, Dong and Van Vleck, 1989, Hoekstra *et al.*, 1994). Because it is essential in New Zealand that a heifer calves at

TABLE 2: Means and standard deviations for Friesian and Jersey in first and second lactation

	1st lactation				2nd lactation			
	Friesian (n = 26393)[b] (n_{CI} = 23047)[c]		Jersey (n = 14345) (n_{CI} = 12655)		Friesian (n = 22141) (n_{CI} = 18753)		Jersey (n = 12527) (n_{CI} = 10688)	
Trait [a]	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
SMFM	18.7	20.2	15.2	16.1	19.4	22.1	14.0	14.9
SMCO	33.3	31.9	29.9	29.8	32.7	31.9	28.0	28.1
CFM	86.6	22.4	81.7	20.5	76.1	21.2	73.2	20.0
FMCO	14.5	26.3	14.7	26.1	13.3	24.5	13.9	24.6
DO	101.1	32.7	96.4	31.9	89.5	30.0	87.1	29.5
CI	375.8	26.0	372.5	25.5	365.7	24.1	364.8	24.1
AC	731.5	22.8	732.8	22.0	1106.6	23.9	1104.9	22.5
NS	1.49	.73	1.51	.74	1.48	.72	1.52	.74
PR21	.46	.50	.52	.49	.47	.50	.54	.50
PR42	.73	.45	.77	.42	.74	.43	.79	.40

[a] Traits: SMFM: Interval from start of mating (STOM) to first mating; SMCO: Interval from STOM to successful mating; CFM: Interval from calving to subsequent first mating; FMCO: Interval from first to successful mating ; DO: Interval from calving to successful mating; CI: Interval between consecutive calvings; AC: Age at calving; NS: Number of service (artificial and natural matings) per conception; PR21: Cow pregnant day 21 after STOM; PR42: Cow pregnant day 42 after STOM

[b] n: Number of observations for SMFM, SMCO, CFM, FMCO, DO, AC, NS, PR21, PR42

[c] n_{CI}: Number of observations for CI

the age of two years and then maintains a calving interval of 365 days, it is likely that the selection pressure for fertility performance in New Zealand is higher than under non-seasonal production conditions.

The means for CFM in New Zealand Friesian correspond well with the values obtained for European Friesian. For FMCO and DO, however, the means are up to 8 days shorter in New Zealand than in Europe. Means for these three traits of American Holstein Friesian are considerable higher than those of New Zealand and European Friesian (Berger *et al.*, 1981, Raheja *et al.*, 1989, Silva *et al.*, 1992). For European Friesian, Janson (1980a,b), Berger *et al.* (1981), Jansen *et al.* (1987), Van Arendonk *et al.* (1989) and Hoeckstra *et al.* (1994) reported means of 77 and 84 days for CFM, 22 to 27 days for FMCO and 95.0 to 100.3 days for DO.

The number of matings per conception obtained in this study is smaller than those reported in other New Zealand studies (1.64 by Macmillan, 1987 and 1.6 by Xu, 1995), but is similar to overseas results of 1.47 (Van Arendonk *et al.*, 1989) and 1.55 (Raheja *et al.*, 1989).

The means for SMFM and SMCO from the present study are higher than those reported by Macmillan (1987, 1995) and Xu (1995). Macmillan (1987, 1995) obtained means of 12.9 and 9.9 days for SMFM and 24.8 and 21.9 days for SMCO, while Xu (1995) reported a mean SMCO of 21.2 days.

The distribution for SMFM indicates that the highest number of matings occurred on the day of the start of mating in a particular herd. The reason for this phenomenon may be that farmers also inseminate on the first day of AB cows that were in oestrus one or more days earlier. Although the pregnancy rate of 54% on day 0 was lower than the 56% at day 1 or 2 and the 60% at day 4, the total number of cows conceived on day 0 was more than that if the farmer waited 21 days for the cows to show oestrus again. This circumstance may also partly explain why the numbers of first matings decrease after day 18 instead of day 22. These cows have been inseminated already on day 0.

The differences in CI, DO and CFM of about 10 days between the first and second lactation could be due to the fact that the start of mating for heifers are normally up to 7 days earlier than the older cows in a herd and to the fact that first lactating cows need longer days to start cycling again than older cows. In the second lactation the means for all interval traits are considerably smaller than those reported in overseas studies (eg Berger *et al.*, 1981, Jansen *et al.*, 1987, Raheja *et al.*, 1989).

Differences in means of different fertility traits for different breeds do exist in literature. Schneeberger and Hagger (1984) reported for Brown Swiss days open of 86.8 days, whereas Mäntysaari and Van Vleck (1989) obtained for Finnish Ayrshire days open of 110 days. Although the differences between breeds were not statistically significant, the Jerseys were consistently superior to Holsteins in their reproductive performance McDowell (1982).

Even under the New Zealand condition where there is a uniform breeding objective across breeds, there exists breed differences in fertility. Jerseys need a shorter time period to show oestrus after STOM. Means for SMFM, SMCO, CFM, DO and CI were shorter for Jeseys than for Friesians and this trend was consistent across both lactations. The percentage of cows pregnant after 21 or 42 days of mating was higher for Jerseys than for Friesians. Friesians are mated later but they need fewer services to conceive. Compared to the Jerseys, Friesians have a shorter interval from first to successful mating. Therefore, Friesian cows tend to be more fertile per insemination but their submission rate is lower. Since it is economically crucial in New Zealand to have a high pregnancy rate in the first 21 to 42 days after start of mating, these breed differences in fertility may become very important in the future.

In conclusion, fertility of New Zealand dairy cows is generally higher than that of cows overseas. SMFM and SMCO and the alternative traits of PR21 and PR42 reflect best the critical points in the reproduction cycle under seasonal conditions and should be used as selection criteria for female fertility. Jersey cows resume oestrus cyclicity earlier than Friesian cows as measured in days from STOM to first mating (SMFM), but conception rate is higher in Friesian than in Jersey cows. The main breed difference and possible beneficial crossbreeding effects on the fertility traits need to be investigated in more detail in further studies.

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REFERENCES

Berger, P.J., Shanks, R.D., Freeman, A.E. and Laben R.C. 1981. Genetic Aspects of Milk Yield and Reproductive Performance. *Journal of Dairy Science* **64:**114-122

Dong, M.C. and Van Vleck, L.D. 1989b. Correlations Among First and Second Lactation Milk Yield and Calving Interval. *Journal of Dairy Science* **72:**1933-1936

Grosshans, T., Xu., Z., Burton, L.J. and Johnson, D.L. 1996. Genetic parameters for fertility traits in seasonal dairy cattle. *Proceedings of the New Zealand Society of Animal Production.* **56:** 37-41.

Hansen, M. 1979. Genetic Investigations on Male and Female Fertility in Cattle. *Livestock Production Science* **6:** 325-334

Hoeckstra, J., Van der Lugt, A.W., Van der Werf, J.H.J. and W. Ouweltjes. 1994. Genetic and Phenotypic Parameters for Milk Production and Fertility Traits in Upgraded Dairy Cattle. *Livestock Production Science* **40:** 225-232

Jansen, J., Van der Werf, J. and W. De Boer. 1987. Genetic Relationships between Fertility Traits for Dairy Cattler in Different Parities. *Livestock Production Science* **17:** 337-349

Janson, L.1980a. Studies on Fertility Traits in Swedish Dairy Cattle. I. Effects of non-genetic factors. *Acta Agriculturae Scandinavia* **30:** 109-124

Janson, L.1980b. Studies on Fertility Traits in Swedish Dairy Cattle. II. Genetic parameters. *Acta Agriculturae Scandinavia* **30:** 427-436

Macmillan, K.L., Day, A.M., Taufa, V.K., Henderson, H.V. and Allison, P.A. 1987. Some Effects of Injecting a Prostaglandin F2, (Lutalyse) during post-partum period on the subsequent fertility of dairy cows. *Proceedings of the New Zealand Society of Animal Production* **47:** 65-68

Macmillan, K.L., Day, A.M. and Taufa, V.K., 1995. Comparative Reproductive Performance of Cycling and Anoestrous Cows in

Five New Zealand Dairy Herds. *New Zealand Veterinary Journal,* in press.

Mäntysaari, E. and Van Vleck, L.D. 1989. Estimation of Genetic Parameters for Production and Reproduction in Finnish Ayrshire Cattle. *Journal of Dairy Science* **72:** 2375-2386

McDowell, R.E., 1982. Crossbreeding as a System of Mating for Dairy Production, Southern Cooperative Series. Bulletin No. 259, July 1982

Philipsson, J. 1981. Genetic aspects of female fertility in dairy cattle. *Livestock Production Science* **8:** 307-319.

Raheja, K.L., Burnside, E.B. and L.R. Schaeffer. 1989. Heifer Fertility and Its Relationship with Cow Fertility and Production Traits in Holstein Dairy Cattle. *Journal of Dairy Science* **72:** 2665-2669

SAS Institute Inc. 1989. SAS/STAT User's Guide, Version 6, Fourth Edition. Cary, NC. SAS Institute Inc.

Schneeberger, M. and Ch. Hagger. 1984. Genetic Parameters for Days Open, Milk Yield, and Fat and Protein Content of Swiss Braunvieh Cows. *Livestock Production Science* **11:** 261-268

Silva, H.M., Wilcox, C.J., Thatcher, W.W., Becker, R.B. and Morse, D., 1992. Factors Affecting Days Open, Gestation Length, and Calving Interval in Florida Dairy Cattle. *Journal of Dairy Science* **75:** 228-293

Van Arendonk, J.A.M., Hovenier, R. and De Boer, W., 1989. Phenotypic and Genetic Association between Fertility and Production in Dairy Cows. *Livestock Production Science* **21:** 1-12

Xu, Z.Z., Burton, J.R., Burton, L.J., Macmillan, K.L. 1995. Reproductive Performance of Synchronised Lactating Dairy Cows. *Proceedings of the New Zealand Society of Animal Production* **55:** 222-244

Sperm numbers, semen age and fertility in fresh and frozen bovine semen

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ABSTRACT

The consequence of a seasonal mating pattern is that a significant amount of semen from the top sires is required during this intensive mating period to satisfy the demand. To utilise semen from these top sires efficiently, liquid semen technology has been extensively used in New Zealand. This paper describes the essential physiological differences between liquid and frozen semen and their relative advantages and disadvantages. Alternative technologies such as freezing semen in bulk and later rediluted for use as liquid semen can be used to overcome the constraints of an intensive mating season.

Keywords: Liquid semen; sperm numbers; frozen bovine semen

INTRODUCTION

Genetic gain in the New Zealand dairy herd is dependent upon two processes: usage of the top genetic merit bulls and the selective rearing of high breeding index calves as replacements. To this end, artificial insemination has remained the main vehicle for the rapid dispersal of valuable genes within the dairy industry. The herd average breeding index (BI) is a good indicator of the genetic progress made in that herd relative to a base BI value established in 1960. A 37% increase in genetic merit has been recorded and nationally, it is estimated that 30% of this genetic gain is exclusively attributable to the use of artificial insemination (P. Shannon, unpublished information). Much of the advancement of artificial insemination is singularly due to advances in semen technology which has allowed the dairy industry to maintain a steady level of genetic progress. The requirements of large volumes of semen from high genetic merit bulls during an intensive mating period has meant that along with the standard frozen semen procedure, an indigenously developed liquid semen system has worked well to spread the top bulls around the national dairy herd (Shannon, 1978, Curson *et al* 1991). The immediate advantage of this system is that fertility is maintained with low numbers of total sperm in the inseminate and thereby increases the coverage of the bull.

THE BREEDING SEASON

The distribution of inseminations from the 1st of September to the 31st of December is shown in Figure 1. In this period close to 3 million inseminations are conducted. The peak usage of semen is during the weeks between October 27th and November 10th where close to 60% of the dairy cattle population in New Zealand are inseminated. During these days the average despatch of liquid semen range from 45,000 to 75,000 individual doses for a three day period of use. To satisy this semen demand, three technologies are extensively used;

- Fresh semen (Long Last Liquid® semen) stored at ambient temperature (15°C to 21°C) and used over a three day period (Curson *et al*, 1991). This accounts for 80% of the inseminations.
- Frozen semen - 15% of the inseminations.
- Bulk frozen semen rediluted as fresh - 5%.