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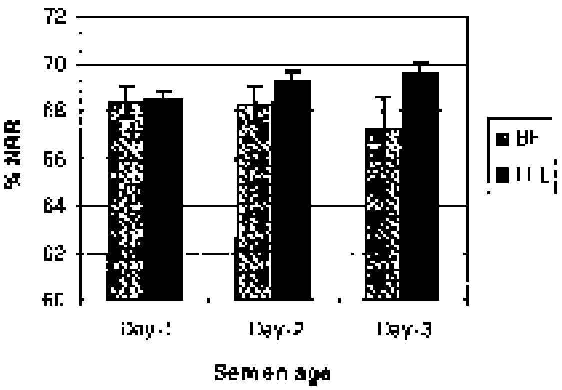
FIGURE 5: Comparison of non return rate between bulk frozen semen and liquid semen on days 1 to 3 after thawing / rediluting and collection respectively.



shelf life of up to four days of use in the field. If the semen age effects can be combated, the efficiency and utilisation of liquid semen could be increased quite significantly. The essential difference between liquid and frozen semen lies in the response of bulls to sub-optimum dose rates. Whilst all bulls respond similarly to sub-optimum dose rates with fresh semen, the response varies greatly when semen was frozen. This means that higher than required dose rates are recommended for frozen semen because of the possibility of a bull x dose rate interaction. The use of bulk frozen semen rediluted to cover those days of high semen demand is another option to combine the convenience of frozen semen technology with the efficiency of liquid semen.

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Reproductive efficiency in lactating dairy cows

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ABSTRACT

Both genetic improvement and milk yield of dairy cows are dependent on a high reproductive performance. Under normal situations, oocyte fertilisation rates following insemination at the appropriate time are high (>90%) and gross genetic defects in embryos are estimated to be around 10%. This means that the biological limit of conception rate should be around 80%. Such a performance has rarely been realised in practice, with 60% being a normal target for lactating cows in New Zealand dairy herds. At a herd level, reproductive performance is best measured by the percentage of cows pregnant within a period after start of the breeding season and this is determined by the combination of submission rate and conception rate. Major factors that affect reproductive performance in New Zealand dairy herds include anoestrus, errors in heat detection, fertilisation failure and embryo mortality. Given adequate nutrition, herd management is undoubtedly the major determinant of reproductive efficiency. The low reproductive efficiency in dairy cows creates a bottleneck to genetic improvement and is a major factor affecting milk production efficiency.

Keywords: fertility; reproductive efficiency; dairy cattle.

INTRODUCTION

Under the New Zealand seasonal dairy production system, the reproductive performance of dairy cows is undoubtedly one of the most important determinants of production efficiency and profitability. Both milk production and genetic improvement of dairy cows are heavily dependent on a high reproductive efficiency. Reproductive performance affects the rate of genetic gain by influencing the number and quality of replacements produced per cow and the rate of involuntary culling due to reproductive failures. As a result of a less than desirable reproductive performance, genetic gain in the national dairy herds has mainly come from the use of AI with semen from proven bulls. A poor reproductive performance, which delays the mean calving date and increases calving spread, also reduces milk yield per day of herd life (Macmillan, 1979).

While the importance of reproductive performance has been well recognised, its true potential has rarely been achieved in practice. Whereas a conception rate (CR) of 60% is considered a normal target for lactating dairy cows, CR of cows in well-managed herds can be a lot higher than 60% (Xu *et al.*, 1995). Table 1 shows the results of a recent trial conducted on commercial herds throughout New Zealand. The results show that, of the cows identified as cycling based on premating heats or rectal palpation prior to the start of mating, 96% were mated during the first 3 weeks; 69% were confirmed pregnant to first insemination; 77.5% to second insemination; and 89% were confirmed pregnant after a 7-week AI period. Another 6% of these cows were pregnant to bull matings after the AI period and only 5% were confirmed empty. No special supplement feeding was used in any of these herds and heat detection was based on tailpaint and visual observation.

TABLE 1: Reproductive performance of cycling, untreated cows in five herds throughout New Zealand during the 1994/1995 season[a].

Herd	Number	Sub21(%)	CR1(%)	CR2(%)	ICR(%)
1	56	96	78.6	77.8	91
2	73	97	76.7	76.5	96
3	77	99	79.2	84.6	95
4	151	96	63.6	86.5	85
5	160	95	62.5	69.8	86
Total	517	96	69.1	77.5	89

[a] Sub21 = 21 day submission rate; CR1 = conception rate to the first round of AI; CR2 = conception rate to the second round of AI; ICR = percentage of cows confirmed pregnant after a 7-week AI period; all conception rate are based on pregnancy diagnosis carried out 6 weeks after the end of AI matings.

In order for a successful pregnancy to occur in lactating dairy cows, many physiological events have to take place in a timely and coordinated fashion. The cow needs to initiate ovarian cyclicity, with ovulations being accompanied by oestrous behaviour. The herd owner must correctly identify cows in oestrus and present them for AI at the appropriate time. Following fertilisation, the embryo must undergo normal development to initiate maternal recognition of pregnancy and to implant successfully in the uterus. The resulting pregnancy needs to be maintained to term, with the birth of a live calf after a normal calving. Failure in any one event will result in reproductive failure. The objective of this paper is to discuss some of the factors that can significantly affect the reproductive performance of lactating dairy cows.

Measurements Of Reproductive Performance

Before the effects of any factors on reproductive performance can be investigated, an appropriate measure(s) that can be used to quantify reproductive performance needs to be defined. Many criteria have been used to describe reproductive performance of dairy cows in New Zealand. From an economic point of view, the mean day of calving from the planned start of calving (PSC) and calving spread are the most important factors affecting milk production and subsequent reproductive performance (Macmillan, 1979). However, calving performance is a reflection of mating performance during the previous season. Therefore, in order to improve reproductive performance, criteria related to mating performance should be used. The percentage of cows in calf over a period from the start of the breeding season (in-calf rate) and percentage of cows that are not pregnant by the end of the mating season (empty rate) are the two most important criteria for mating performance. In-calf rate affects calving performance and empty rate affects the rate of involuntary culling. In-calf rate incorporates other mating performance parameters, such as submission rate and CR (Macmillan & Watson, 1973). In practice, CR is often measured by the non-return rate (NRR) over a certain period after insemination. Abortion rate is another reproductive performance parameter, but abortion rate not associated with nutrient deficiencies and diseases is generally low and does not vary significantly. Thus, in order to achieve a high reproductive performance (measured by in-calf rate), herd owners should strive to submit as many cows as possible for AI during the first 3 to 4 weeks of the breeding season while at the same time achieve a high CR (Macmillan & Watson, 1973).

Postpartum anoestrus

Anoestrus at the start of the breeding season is a serious reproductive inefficiency in New Zealand dairy herds. The percentage of anoestrous cows in well-managed herds varies between 10% to 35% (Xu & Burton, unpublished data). Date of calving relative to the PSC and feed supply during the precalving and early postcalving periods are the main causes for variation in the percentage of anoestrous cows. In addition, induced cows, primiparous 2-year-old cows and Friesian cows at high stocking rate all take a longer time to initiate cyclicity post calving and contribute to the population of anoestrous cows (McDougall, 1993).

For most cows that have calved normally, anoestrus at the start of the breeding season is not of a problematic nature, but is a condition imposed by management requirements to maintain a 365-day calving interval. To achieve a 365-day calving interval, breeding needs to start 83 days from the planned start of calving (assuming gestation length is 282 days). Under the pasture farming condition in New Zealand, the first oestrus occurs on average more than 6 weeks after calving (Xu & Burton, unpublished data; McDougall *et al.,* 1995; Macmillan *et al.,* 1996). Therefore, a cow has to calve in the first 5 weeks after PSC if she is going to have a good chance to be cycling at the start of mating. However, up to 25% of the cows in a herd may calve during the 6 weeks immediately prior to start of mating (Macmillan *et al.*, 1990). Under adverse environmental conditions, over 90% of these cows will not cycle by the start of the mating season (Xu & Burton, unpublished data).

Thus, a key component to improvement of reproductive performance in New Zealand dairy herds is to calve as many cows as possible in the first 5 weeks after PSC so that they will have sufficient time to initiate cyclicity prior to the start of mating. Treatment of anoestrous cows with oestradiol and progesterone can result in 85% of the treated cows being detected in oestrus and inseminated within 5 days of treatment with a CR of 45% (Xu & Burton, unpublished data). Anoestrous cows should be identified and treated prior to start of the breeding season, so that treated cows returning to service can have a second or a third chance to be mated by AI.

Errors in heat detection

With the widespread use of AI for generating replacements, errors in heat detection will significantly affect reproductive performance during the AI period. There are basically two main types of heat detection errors. The first type is the failure to detect cows in heat (efficiency). Each failure to detect a cow in heat means a delay of mating by one cycle (21 days). The other type is errors in oestrus detection (accuracy) which will result in inseminations of non-oestrous cows. While inseminations of cows not in heat will waste semen, its biological effect will depend on if the non-oestrous insemination is preceded by an oestrous insemination. A non-oestrous insemination has little effect on CR to a subsequent insemination but will significantly reduce the CR to a preceding oestrous insemination (Macmillan *et al.,* 1977).

The magnitude of heat detection errors in commercial dairy herds is hard to measure. Using plasma concentrations of progesterone as a criterion, it has been shown that up to 20% of cows in the USA may be inseminated at the wrong time (Senger et all., 1988). To some extent, heat detection errors can be estimated by analysing return interval data. Because cows very rarely have an oestrous cycle shorter than 6 days, the accuracy of heat detection can be estimated by the percentage of cows that return to service between 2 to 5 days after a previous insemination. Assuming that accuracy of heat detection is the same across the 21 days of an oestrous cycle, multiplying the above percentage by 5 will yield an estimate of the error rate of heat detection. In addition, the percentage of cows with a return interval that is a multiple of the normal oestrous cycle length (18 to 24 days) will yield a slightly over-estimated measure of the efficiency of heat detection. Experience and time are the keys to improving the efficiency and accuracy of heat detection. While proper use of heat detection aids, such as tailpaint and Kamar Heatmount detectors, will facilitate heat detection, they can not replace visual observation, which should be carried out several times a day and last at least 30 min on each occasion. Errors in heat detection affect both submission rate and CR.

Fertilisation failure

Fertilisation failure implies failure of a spermatozoon to penetrate and activate the egg. However, such information is seldom available for farm animals under field situations. In addition, failure of fertilisation could be caused by incorrect timing of insemination. In polytocous species such as the pig, fertilisation rate for animals that had at least one fertilised egg is high (>90%; Polge, 1978; Hunter, 1994). In normally cycling cows, fertilisation rate to a single insemination at the appropriate time with semen of proven fertility can be higher than 90% (DeJarnette *et al.,* 1992; Screenan & Diskin, 1986; Nadir *et al.,* 1993). However, under field conditions, fertilisation failure may account for 20% or more of reproductive wastage (Ayalon, 1978; Hunter, 1994). Factors known to have a major influence on fertilisation rate include: sires, semen processing, site of insemination, dosage of sperm, timing of insemination relative to ovulation, exogenous hormonal manipulation of the reproductive cycle, postpartum interval, cow fertility, and others (Nadir *et al.*, 1993; Hunter, 1994).

Embryo mortality

Embryo mortality represents a major component of reproductive wastage in dairy cows. Up to 38% of fertilised zygotes may die before calving (Ayalon, 1978; Sreenan & Diskin, 1986). The estimated magnitude and timing of embryo mortality in cattle differ greatly among studies, ranging from 8% to 42% when measured before day 42, with most losses occurring between day 8 and day 16 (Sreenan & Diskin, 1986; Zavy, 1994). After the completion of implantation (about day 42), only about 5-8% of foetuses are lost prior to calving (Sreenan & Diskin, 1986). Apart from the small numbers of observations involved in some studies, large variation in estimates of embryo mortality rate indicates the likely involvement of many factors. Some of these factors include genetics, semen quality, timing of insemination, nutrition, physiological and health status of the cow (Zavy, 1994).

Most embryonic losses are due either to genetic defects in the embryo itself and/or to failure of maternal recognition of pregnancy. Based on chromosomal analysis, about 10% of embryos are abnormal, with most of the abnormal embryos being 7 days of age or less (King, 1990). In addition, lethal mutations and recessive genes not identifiable by chromosomal analysis will also cause embryo mortality. Both male (semen quality, dosage of sperm) and female (oocyte quality, uterine environment, physiological and health status) factors as well as the time of insemination relative to ovulation can affect embryo quality, which may result in abnormal embryo development and failure to establish pregnancy (DeJarnette *et al.,* 1992; Nadir *et al.,* 1993; Mihm *et al.,* 1994; Hunter, 1994). Some embryo mortality could be caused by the inability of the embryo to prevent the initiation of luteolysis as a result of asynchrony between the stage of embryo development and onset of luteolysis. Treatment of cows post insemination with progesterone or GnRH to delay onset of luteolysis can increase CR (Macmillan *et al.,* 1986, Sheldon and Dobson, 1993).

Management to achieve a high reproductive performance

If we assume that fertilisation rate is 90% and 10% of the embryos have gross genetic defects, the theoretical limit to CR following a single insemination can be as high as 80%. From the above brief discussion, it is clear that many factors can act alone or in combination to reduce reproductive performance to levels much lower than 80% in lactating dairy cows. The importance of the various factors differs under different environmental and management conditions. Given adequate nutrition, management is probably the most important factor determining reproductive performance. Management affects almost every aspect of the reproductive process. Management for achieving a high reproductive performance should start prior to calving to ensure that cows calve at the appropriate body condition. After calving, cows should be managed to minimise body condition loss. Anoestrous cows and cows with reproductive disorders need to be identified and treated prior to the start of mating. Once the breeding season has started, every effort should be made to accurately detect all cows in heat and present them for insemination at the appropriate time with semen of proven fertility. If all these management aspects are taken into account, reproductive performance close to the theoretical target can be achieved (Table 1).

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