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Dairy Cattle Reproduction

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INTRODUCTION

Obtaining optimal reproductive performance from a herd of cattle requires a knowledge of the basic principles of and factors affecting reproduction, an understanding of managemental strategies which can be employed to achieve such performance, and an awareness of existing and new technological advances which can be applied in the farm situation. All of these topics are put together in the series of papers included within this book, which were written to provide background material for a workshop on cattle reproduction held at Lincoln College, May 1984. The workshop participants include scientists, veterinarians, farm advisers and farmers. It is hoped that in addition this book will provide a useful text for a wider range of readers.

A summary is provided at the start of each section to assist any reader who does not wish to examine each topic in the detail provided in the individual papers.

G. K. Barrell
May, 1984.

DEFINING REPRODUCTION

SUMMARY OF THIS SECTION

In N.Z. the level of fertility of dairy cattle is generally very high. When reproductive performance in a herd falls below an acceptable level of success it is usually due to poor planning of a breeding programme or under-nutrition at critical stages of the breeding cycle.

The management objectives are spelt out in the paper contained in this section. Successful reproductive management involves getting many cows pregnant in a short space of time so that a concentrated calving pattern can be obtained. Other reproductive objectives include genetic improvement of the herd for increased production and building up herd size whilst simultaneously culling low producing cows.

These objectives are maximised by maintaining a calving interval close to 365 days and a short calving pattern in which median date of calving occurs within 15 days of the planned start of calving. The spread of calving dates exhibited by many N.Z. herds indicates that there is considerable scope for improving this latter objective.

Artificial breeding (AB) offers a reliable method for increasing the genetic potential of a herd by the use of semen from progeny tested bulls.

DEFINITION AND OBJECTIVES OF REPRODUCTION IN DAIRY COWS

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Introduction

Reproductive difficulties are among the most common and serious problems that occur in dairying. A number of causes can be listed and no single one necessarily applies to all herds.

(a) Failure to cycle.
(b) Failure to be mated.
(c) Failure to conceive.
(d) Early embryonic mortality.
(e) Abortions.
(f) Dystocia.
(g) Neonatal mortality.

Successful reproduction involves the placement of fertile spermatozoa, either by a competent technician or a bull, into the uterus of a fertile cow during or shortly after oestrus, followed by conception and normal pregnancy. A successful herd breeding programme requires definition of short term and long term objectives,the derivation of a management plan, and objective measurements to gauge success or failure during the implimentation of the plan and its completion. Submission rate (SR), the percentage of the herd mated or inseminated at least once during the first four weeks of the breeding programme, is the only promptly available statistic for the progressive assessment of a breeding programme. Submission rates of 90% and above are common and depend on a high proportion of the herd cycling and being accurately recorded in oestrus. The long-term measure of the success of a breeding programme is the percentage of the herd diagnosed as empty at drying off or when culling occurs. Empty cows are usually confirmed by rectal palpation of the uterus and rarely exceed 6% of the herd. Subsequent papers in this publication will discuss factors which influence successful reproduction in dairy cattle. In this paper the breeding objectives and level of reproductive success obtained in the N.Z. dairy industry will be discussed.

Breeding Objectives

Breeding objectives will differ in importance for different herd owners; a priority order for many is as follows.

(a) To get as many cows pregnant as possible.
(b) To maintain a seasonally concentrated calving pattern.
(c) To cull the highest proportion of low-producing cows in the herd while maintaining or increasing herd size.
(d) To improve future production by genetic improvement of the herd.
(e) To produce replacements that meet individual farmer's standards for conformation.

(a) Getting cows pregnant.

The initiation of milk production is still entirely dependent on the establishment of pregnancy and the accomplishment of a normal or induced parturition. However research continues on hormonal induction of lactation in dry cows (Davis *et al.,* 1981) a technique which may ultimately reduce wastage rate due to infertility. High energetic and economic efficiency of milk production is obtained when an individual cow's lactation yield is optimized within a 365 day calving interval (Esslemont, 1979).

Longer breeding programmes in N.Z. dairy herds reduce the number of empty cows. For example if two herds have similar conception patterns but one herd has a longer mating period this herd will have fewer empty cows. In recent surveys in Waikato dairy herds (Macmillan and Clayton, 1980; Macmillan *et al.*, 1981) the percentage of empty Jersey cows decreased from 12% to 4% as the mating period was increased beyond 13 weeks.

Surveys in tested herds found that wastage rate due to low fertility was between 3% and 5% but was influenced by age structure since the value increased from 2.5% in 2-year-old cows to over 8% in cows 10 years and older (Macmillan and Murray, 1974).

(b) Concentrating calving.

In many overseas countries the calving interval (CI), i.e. the average period between consecutive normal calvings of individual cows within a herd, is an indicator of reproductive efficiency. The average CI in seasonal herds is 364 days (Macmillan and Moller, 1977) compared to 384 days in town supply herds (Fielden *et. al.* 1980). These figures compare favourably with those from herds in the U.S.A. and U.K. where calving intervals of 395 days and longer are commonly recorded (Shrestha, 1978). It should be noted however that CI does not account for cows that calve only once or those that fail to get in calf. For these reasons CI may not be a very reliable measure of reproductive efficiency.

One of the most critical decisions made by seasonal supply dairy farmers is the date on which the breeding programme will begin. This dictates the planned start (PS) of calving 282 days later and together with the conception pattern, allows prediction of the feed demand of the herd.

Because variation in calving date is the major factor influencing lactation length among cows within a herd (Macmillan *et al.*, 1981), monitoring and control of calving patterns is important. Provided adequate preparations are made to feed cows well in early lactation (Bryant and MacDonald, 1983), each extra day of lactation achieved by concentrating the calving pattern, should increase yield by 0.7 to 0.9 kg milk fat/cow/day (Macmillan, 1979). A concentrated calving pattern depends on the conception rate (CR), the submission rate (SR) and can be further concentrated by induction especially when expected calving dates are known (see Macmillan, both papers, and Day; this publication). Concentrating the calving pattern also concentrates other seasonal activities such as rearing of young stock. It is not enough, however, to study only the calving date and the spread of calving. Calving programmes can be studied to identify the strong and weak points of the previous mating programme.

Calving programmes can be evaluated by studying; (a) the interval from the planned start (PS) of calving (282 days after inseminations commenced) until 50% of the cows have calved, (b) the interval over which the next 25% of cows calved, and (c) the interval over which the last 25% of cows calved. This division of the calving pattern allows different aspects of herd management to be assessed.

The interval from PS to median calving date (time taken for 50% of the herd to calve) will indicate the success of the insemination programme.This indicates the proportion of the herd which cycled, was detected in oestrus and conceived early in the previous mating period. Intervals of 15 days or less reflect a high SR and a satisfactory CR to first insemination. The interval from median calving date until 75% of the herd have calved will be influenced by the CR and the efficiency of oestrous detection after the first 3 weeks of mating. It can be particularly difficult to detect cows in oestrus during this period as the number of sexually active groups of cows in the herd have greatly diminished.

TABLE 1.

Calving pattern intervals in 35 Matamata herds and a Ruakura herd in 1982 (from Macmillan *et al.,* 1984).

Interval	Mean	±S.D.	Range	Ruakura No. 2
PS* (date)	5 Aug	7.1	23 Jul-18 Aug	15 Jul
PS to median (days)	18.3	3.5	12-25	15
Median to 75% (days)	18.3	3.5	12-25	15
Last 25% (days)	36.3	17.4	12-72	19
Total calving (days)	71.9	17.0	45-107	46

*Planned starting date of calving.

The third interval reflects the length of the breeding programme,the percentage of the herd induced and when the cows were induced.It also indicates the level of induction or culling required if a desired calving spread is to be achieved in the following calving. Calving patterns in 35 Matamata herds and the Ruakura No. 2 herd are shown in Table 1. Calving lasted 71.9 days from PS in the Matamata herds compared with 46 days in the Ruakura No. 2 herd. This difference arose from the extra time taken by the last 50% of the Matamata herd to calve. Although a slightly higher proportion of cows was induced in the Ruakura No. 2 herd (15.8% vs 11.4%), the earlier use of induction was of far greater importance in the attainment of the more concentrated calving pattern. If the Matamata survey figures depict the general N.Z. calving pattern, there is scope for increasing the average herd lactation length by at least 7 days without altering mean calving date. The calving pattern of heifers is directly related to rearing management, with over 90% calving in the first seven weeks in commercial herds (Macmillan, 1976).

At present, induction of calving is used to improve the calving pattern in 77% of N.Z. dairy herds, with an average of 16 cows induced per herd, or 11% of all cows milking. Corresponding South Island figures are 65%, 16 and 13% (N.Z. Dairy Board, 1982).

(c) Culling low producers.

Most herd owners produce their own replacements but some are prepared to buy in replacements. Herd wastage rates vary from 12% to 28% and wastage is the major factor influencing replacement rates. Over the period from 1938/39 to 1976/77 the total wastage rate ranged between 17% and 21% (N.Z. Dairy Board, 1982). In N.Z. today the typical replacement rate probably lies somewhere in this range. Herd wastage is often divided into a planned and an unplanned component. The major causes of unplanned wastage are; failure to conceive, mastitis, metabolic diseases, and bloat. Management may influence some of this wastage such as empty but fertile cows and deaths due to bloat and facial eczema. Planned wastage involves cows culled for low production, unsuitable temperament, or poor conformation and old age. Wastage levels show no apparent trend with increasing herd size (*Table 2*). However, no account is taken of stocking rate which may affect the incidence of disease or the importance of culling for low production. Only a small percentage of cows are culled for reproductive problems (3.5%) or low production (5.1%). In some herds the 10% of cows with the lowest production contribute less than 6% of the total production of the herd (Hook, 1983). Large improvements in production could be made by increased culling for low production, as long as superior replacements are available.

TABLE 2.
Trends in wastage (% culled) according to herd size in L.I.A.-recorded herds in New Zealand (after N.Z. Dairy Bd., 1982).

Causes of wastage	Average herd size (cows) 120-159	160-199	200 & over	All herds
Low production	5.1	4.9	5.6	5.1
Causes unassociated with disease	6.0	5.8	5.6	6.0
Bloat	0.7	0.7	0.5	0.6
Mastitis	1.0	1.1	0.8	1.0
Reproductive	3.7	3.5	3.0	3.5
Other disease	1.1	1.1	0.9	1.1
Total wastage	17.6	17.1	16.3	

Unless replacement rate is high (25%), unplanned wastage reduces the scope for planned culling of low producing cows thereby reducing the potential production of the herd.The replacement rate for a herd should be at least 10% higher than the unplanned wastage rate so that low producers can be culled from the herd.

A recent analysis of the effect of replacement rates on dairy farm productivity and profitability (Jackson, 1983) suggests that moderate replacement rates (20%) are likely to be the most profitable. Economic analysis indicates that as replacement rate increases the total cost of rearing these additional replacements also increases. The procedure will be profitable provided the additional production generated by the higher replacement rates meets the additional costs associated with their rearing. There is no excuse for not rearing sufficient herd replacements as calf rearing techniques have been simplified in recent years, there is a shortage of traditional beef, a demand for heifers for export and expansion of dairying into new regions. Any surplus animals can be therefore be readily and profitably disposed of.

(d) Genetic improvement of the herd.

The most reliable way to improve the genetic merit of a herd is to use replacements bred from semen of progeny tested bulls with high and reliable breeding indices (BIs). Unless herd replacement rates are low (15%) this requires over 90% of the herd to be inseminated over a six week period (Macmillan, 1976). The percentage of cows reported in calf to artifical breeding (AB)which actually produce AB calves (83%), the sex ratio (48% heifers) the calf retainment rate (92%) and the heifer retainment rate(80%) reported by Macmillan suggest that for every 100 cows reported in calf only 29 AB heifer calves are reared. Therefore if the annual replacement rate is is 20% ,69% of the herd would need to be reported in calf to AB. This corresponds to a submission rate of about 90% for a herd with an average CR (67%),using AB for six to seven weeks. The flexibility of the breeding programme can be improved if the herd owner is prepared to inseminate his heifers and rear their female progeny. Surveys of herds using artificial breeding (AB) in 1973 (N.Z. Dairy Board, 1974) showed that only 84% of calves reared were the progeny of AB sires. Furthermore, of the 69% of herd owners who wished to rear solely AB heifers, only 47% achieved this objective. A similar survey among AB users in 1981 (N.Z. Dairy Board, 1982) found that the proportion of AB calves had declined to 73% of all calves reared, but at this time 56% of owners reared solely AB calves. Quite clearly, if genetic improvement of herds is a desired objective a higher proportion of herd replacements will need to result from AB.

(e) Type, conformation, colour and size.

Apart from factors which make cows difficult to milk (e.g. temperament, rate of milking, udder shape and teat placement) or shorten their productive life (e.g. susceptibility to disease), it is difficult to justify the addition of further traits to present selection programmes. Doing so will more than likely decrease the rate of genetic progress for milk yield and milk fat. This is especially likely when there is no agreement or uniformity of measurement amongst those for whom these standards may be important. It is however necessary to monitor the correlated changes that are occurring in order to prevent multiplication of undesirable characteristics.

This last objective of a breeding programme is considered the least important.

Conclusions

Recent surveys have shown that the average level of fertility in N.Z. dairy cattle is very high, although individual cases of infertility still occur. Calving intervals of 364 days in seasonal herds and 384 days in town supply herds, an average pregnancy rate to first insemination between 60% and 65% (Macmillan *et al.*, 1980) and an average herd wastage rate of 21%, are all rarely matched in developed dairy industries elsewhere in the world. Nevertheless there does appear to be scope to increase dairy production by further concentrating the calving pattern and by reducing unplanned wastage.Where individual herd infertility does arise it can probably be attributed to poor breeding management,inadequate disease prevention programmes,insufficient mineral supplementation or under-nutrition at critical stages of the breeding cycle.

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PHYSIOLOGY

SUMMARY OF THIS SECTION

Reproduction in cattle involves more than just the organs of the reproductive tract. The general health, body condition and mobility of cows and bulls are essential requirements for successful reproduction. In addition the hypothalamus in the brain and the pituitary gland just under the brain have an important influence over the reproductive organs and also provide a means by which environmental factors such as daylight or social stress can modify the whole process.

The regulatory links between the gonads (ovaries, testes) and the other glands are provided by hormones and an understanding of the role of hormones has been instrumental for the development of techniques to manipulate cattle reproduction.

In spite of the advances which have been made in the elucidation of reproductive physiology there are still important events which are not understood. These include the question of how some ovarian follicles mature and ovulate (release an egg from the ovary) instead of merely regressing which is the ultimate fate of most follicles. Whilst it is known that the functioning of the corpus luteum (which is formed from an ovulated follicle) can be terminated by a prostaglandin released from the uterus, and this event can be mimicked artificially, it is still a mystery why this is prevented if the egg becomes fertilised. The reasons for the loss of many embryos (about one-third) during the early stage of pregnancy also are not known. Clearly if some of these unexplained issues become better understood then there could be considerable scope for increasing the productivity of breeding cattle.

The paper in the section provides a summary of the current state of knowledge of the processes that regulate the production of egg cells and spermatozoa and culminate in the delivery of a live calf.

PHYSIOLOGY OF REPRODUCTION IN CATTLE

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Introduction

Reproduction in animals is a process which determines the continued existence of a species. Consequently it justifies the involvement of much of the physiological resources of an individual. Whilst specific sections of an animal may be responsible for producing gametes or nurturing foetuses, it is probably more realistic to view reproduction as the combined function of many internal body systems, some of which are influenced by factors originating from external social and physical environments. Because the process is so complex, any simplification will be an over-simplification and any component singled out for scrutiny will gain inappropriate attention in relation to its importance in the whole scheme.

One of the functions of the gonads is to produce gametes (egg cells, spermatozoa) and this is regulated primarily by hormones, called gonadotrophins, which are secreted by the pituitary gland. This gland is stimulated to release the gonadotrophins by gonadotrophin-releasing hormone (GnRH) which is secreted by the hypothalamus. Both the pituitary gland and the hypothalamus are influenced by hormones produced in the gonads. As a result these links between hormones and target organs are arranged in the form of a loop, the final link, in this case between gonadal hormones and the structures associated with the brain, being an example of feedback. Other reproductive functions are regulated by similar convoluted interactions between different hormones. The endocrinology of reproduction therefore must be a central issue in any discourse on reproductive physiology.

Testicular Function

The major products of the testes (male gonads) of adult bulls are spermatozoa and hormones. Spermatozoa are formed from precursor cells (spermatogonia) in walled-off tubes called seminiferous tubules. In conjunction with nutritive support from specialised tubular cells (Sertoli cells) spermatogonia progress through a series of developmental steps within a sequestered environment, somewhat analogous to that provided for oocytes in ovarian follicles. Fluid produced in the tubules carries newly formed spermatozoa into a central duct through which they are conveyed out of the testes. An important accessory structure, also housed within the scrotum, is the epididymis. It is in this latter organ that spermatozoa are stored, gain their ability to move (although they do not actually become motile until ejaculation), and acquire some of the biochemical properties needed for fertilization of ovulated oocytes (ova). Spermatozoa develop their full potential to fertilise ova after they have spent several hours in the female tract.

The secondary sexual glands associated with the male reproductive tract provide additional components of the seminal fluid during ejaculation.

Regulation of Reproduction in Bulls

Both of the pituitary gonadotrophins, follicle-stimulating hormone (FSH) and luteinizing hormone (LH), are required for the successful production of spermatozoa. FSH has target receptors on the Sertoli cells and is instrumental in providing the correct tubular environment for spermatogenesis. On the other hand LH stimulates testosterone production by testicular cells located outside the seminiferous tubules (Leydig cells). From here testosterone diffuses into the tubules where it is needed for satisfactory completion of spermatogenesis. Testosterone also reaches the general circulation and is the main hormone responsible for male sexual characteristics such as libido.

The whole process in bulls is controlled in a similar manner to that described below for cows. Stimulatory signals are transmitted by GnRH and the gonadotrophins, with testosterone producing an inhibitory 'negative feedback' influence over hypothalamic and pituitary function. The gonads of both sexes produce a hormone called inhibin which specifically inhibits the secretion of FSH and which probably provides the fine tuning for the control of gamete production.

Ovarian Function

Reproductive activity in the cow hinges on the state of the ovaries, which produce both egg cells (called oocytes) and hormones. The oocytes are not just scattered about the ovaries in isolation but are each present within a surrounding membrane in association with a cluster of specialised cells (granulosa cells). Another layer of specialised cells (theca cells) appears outside this membrane when these structures become further developed. These structures are called follicles and approximately 40 000 are present in each ovary of a calf at birth. Only a minute fraction of them will eventually ovulate and release an oocyte from the ovary. Follicular death, or atresia, commences before birth and is the fate of about one-third of the remaining follicles each year. Therefore ovulation is a most unlikely fate for a follicle. At any time during adulthood there are always a few follicles either growing or undergoing atresia.

Growth consists of multiplication of the granulosa and theca cells and the accumulation of fluid within follicles so that they take on the appearance of small blisters under the surface of the ovary. Just prior to the start of an oestrous cycle one of the larger follicles in each ovary is rescued from the otherwise inevitable fate of atresia and undergoes marked and rapid increases in size. At this stage follicular cells, especially the granulosa cells, produce large quantities of oestrogens. Recruitment of a follicle into this latter phase of maturation is partly dependent on the provision of a suitable hormonal environment. The number of follicles which ovulate at each ovulation seems to be related to the supply of the gonadotrophin, aptly named FSH. Provision of supplementary FSH, or of FSH-like drugs such as PMSG (pregnant mare serum gonadotrophin), can lead to increased numbers of ovulating follicles, i.e. 'super- ovulation'. This phenomenon has been usefully exploited for embryo transfer procedures.

After ovulation the successful follicle takes on a new appearance. Blood vessels from surrounding ovarian tissue penetrate through the outer membrane, granulosa cells increase in size and the previously fluid-filled follicle is transformed into a solid cell mass — the corpus luteum or yellow body. There is a concurrent change in the hormonal product of the granulosa cells, as the major hormone secreted from the corpus luteum is progesterone. Meanwhile the development and regression of small follicles continues largely unaltered. The ovarian events which characterize oestrous cycles are; the final maturation of a follicle so that it eventually ovulates — (the 'follicular phase'), and the subsequent development and functioning of the corpus luteum — (the 'luteal phase'). If a discharged oocyte is not fertilised, the corpus luteum finally regresses after 16 to 18 days and the whole process is repeated.

Regulation of Oestrous Cycles

The survival of large follicles beyond the atresia barrier depends on pituitary gonadotrophin secretion, which in turn relies on pulses of GnRH released by the hypothalamus. Hypothalamic activity itself can be altered by nervous stimuli arising from sources such as temperature, light and social stress. Other factors to consider are level of nutrition, body condition, stage of body growth, stage of lactation, time since the last calf was born and state of health. These have considerable influence on the release of gonadotrophins, the response of target cells to their specific hormones, and the metabolism and biological half-life of hormones generally. Consequently the mechanisms by which these factors can modify initiation of the crucial, final stages of follicular maturation are not well defined.

Once maturation is initiated the reprieved follicle produces large amounts of oestrogens, mainly oestradiol. At this stage of the cycle oestrogens have a 'positive feedback' effect on the hypothalamus and pituitary because they stimulate secretion of LH (*Fig. 1*). Two major events occur over the next few days. First the elevated gonadotrophin levels increase oestrogen secretion by the follicular cells and the high concentration of oestrogens may be sufficient to cause behavioural oestrus (heat) — although admittedly oestrus does not usually occur at the first pubertal or post-partum cycle. Secondly the enlarged, mature follicle ovulates, gently releasing its oocyte from the ovary, and then undergoes conversion into a corpus luteum. Ovulation requires a surge of LH secretion which must amount to something like the pituitary equivalent of an explosion - an event which only female hypothalamic-pituitary systems are pre-programmed to carry out.

Over the ensuing sixteen days the cow is dominated, reproductively speaking, by the secretion of progesterone. This hormone inhibits hypothalamic function via a 'negative feedback' signal (*Fig. 1*) and consequently impedes any further follicular maturation during the life span of the corpus luteum.

When these events occur without any overt display of oestrus — a

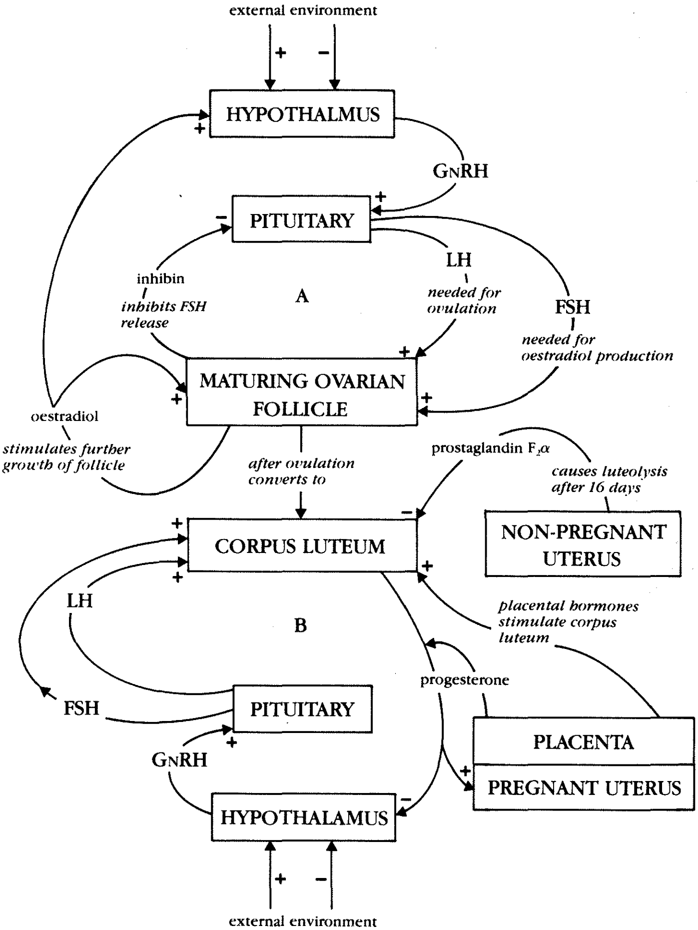

Figure 1: Summary of major hormonal events in a cow; (A) during the final stage of follicular maturation, and (B) when a corpus luteum is present.

so-called 'silent ovulation', or if for some other reason fertilisation does not occur, then the cow faces a crucial reproductive situation. In order for follicular maturation to recommence the inhibitory influence of progesterone must be eliminated. This is achieved by destroying the corpus luteum, an event which depends upon the timely arrival from the adjacent uterus of a hormone known as prostaglandin $F_2\alpha$ (PGF). Once this occurs, and the corpus luteum has been destroyed, another normal ovulation can be expected within a few days. Destruction of the corpus luteum, or 'luteolysis', is probably the key event for control of ovulation and therefore provides the basis for synchronisation techniques.

Fertilisation

Successful fertilisation of mature oocytes (or ova) is largely a matter of correct timing. Some adventitious spermatozoa reach the innermost regions of the female reproductive tract within a few minutes after ejaculation. However their haste is fruitless since spermatozoa must spend at least an hour in the uterus acquiring the final attributes needed for egg penetration. Reservoirs of spermatozoa are stored within folds of the cervix and the progression of spermatozoa from these stores to the site of fertilisation in the oviducts is a continuous and carefully regulated process. Exposure of the female tract to the various hormonal changes leading up to ovulation appears to be an essential prerequisite for this critical but poorly understood process of spermatozoal transport.

An ovulated oocyte reaches the oviduct, usually within 40 minutes of ovulation. It must encounter competent spermatozoa waiting in the upper reaches of this channel if fertilisation is to occur at about six hours after ovulation. With natural mating spermatozoa should be present in the female tract before ovulation, and fertilisation must occur within 24 hours from ovulation.

This integration is achieved in natural mating by the high levels of oestrogens causing standing oestrus to commence about 30 hours before the maturing follicle ovulates. The peak of oestrous behaviour should thus coincide with the optimal time for mating.

Pregnancy

The newly fertilised embryo reaches the uterus three to four days after ovulation, by which time the uterus is under the influence of progesterone secreted from the corpus luteum. This hormone stimulates uterine secretions which nourish the developing embryo until it is implanted. Implantation does not commence for 5 to 6 weeks yet during this time the corpus luteum fails to undergo luteolysis. The embryo apparently produces a signal which prevents the uterus from releasing a luteolytic dose of PGF. The precise nature of this 'pregnancy signal' has yet to be elucidated.

Most of the embryonic and foetal mortality (about one-third of all fertilised eggs) occurs during the first six weeks of pregnancy and for a variety of reasons. For instance, the 'pregnancy signal' may have been inadequate, the uterine environment may be nutritionally or endocrinologically imbalanced, the corpus luteum may fail to maintain an adequate supply of progesterone, or the embryo itself may lack competence for survival. Unfortunately this is another topic where precise information is lacking yet where there is much scope for possible future intervention.

Pregnancy is maintained by progesterone secreted from the corpus luteum. In addition placental tissue provides an extra source of this and other essential hormones during the gestation period. The hormones associated with the pregnancy are instrumental also in developing mammary tissue for the impending lactation.

In the early stages of pregnancy there is a differentiation of parts of the embryo into membranes which develop into an inner amniotic membrane and the outer allanto-chorionic membranes. Cells of the chorion progressively invade the caruncles of the uterus and form the cotyledonary placenta which is unique to the ruminants. Although the blood circulations of mother and foetus are quite separate the placental attachment provides a site of intimate association of blood vessels which allows ready movement of most small molecules between the two organisms. Growth of the placenta is a dominant feature of the first two-thirds of pregnancy whereupon it is overshadowed by foetal growth during the latter third. Throughout pregnancy free development of the foetus is permitted by the cushioning action of the amniotic fluid which surrounds the foetus.

Parturition

Pregnancy ceases when the sources of progesterone are shut off by the action of PGF. This situation arises when corticosteroids from the adrenal cortex of the foetus reach the placenta, causing the release of prostaglandin and the formation of oestrogens. The foetus is thus responsible for triggering its own birth. This chain of hormonal events causes relaxation and softening of connective tissue at various sites in the birth canal and pelvis, stimulates uterine contractions, and also switches on lactation.

Uterine contractions during the preparatory stage of labour force the foetal membranes into and through the cervix. Usually the allanto-chorionic membrane bursts at this stage, releasing a copious volume of allantoic fluid. The amnion usually ruptures during the second stage of parturition when the forefeet of the calf pass through the vulva. As a result the calf is expelled free of the placental membranes. The maternal and foetal components of the placenta separate after calf delivery so that expulsion of the foetal membranes occurs half an hour to 8 hours later, although most cows complete this process in 4 to 5 hours.

In conclusion, the presence of the newborn calf plus its ready source of nourishment represents a successful outcome for the whole reproductive process and an assurance of continued survival for both the bovine species and the cattle industry.

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FACTORS AFFECTING REPRODUCTIVE PERFORMANCE

SUMMARY OF THIS SECTION

The cow.

Two important parameters are used as measures of reproductive performance in the dairy herd. These are; submission rate (SR) which is the proportion of a herd submitted for artificial insemination (A.I.), and conception rate (CR) which is the proportion of inseminated cows in which a conception is established. CR may be partly outside the influence of the herd owner as it depends a lot on factors such as quality of semen and competence of the A.I. technician. On the other hand SR is entirely dependent on factors relating to the herd managers and their management programmes.

These factors include skill at oestrous detection and ability to produce a narrow spread of calving dates in the herd. If an oestrus is missed then it will be at least three weeks before the same cow is likely to be detected again. A wide calving date spread means that some cows will have a short interval from calving to the start of mating. Such late calvers may not be able to start oestrous cycles by this time and even if they do they are likely to have poor CRs. Adequate nutrition could play a major part here since it could help to overcome some of the problems of the late calvers. Condition scoring and increased food supply can be worked together not only to increase the chances of conception but also to produce more milk.

Other factors which influence SR include; age of cows (both young heifers and very old cows cause problems here), errors in the diagnosis of oestrus (it is best to give cows the benefit of any doubt and inseminate them if suspected in oestrus), accuracy of records, large herds (where oestrous detection is impaired), and dystocia and retained foetal membranes, (both of the latter can impair subsequent fertility). Maiden heifers can present special problems unless emphasis is placed on nutrition and parasite control.

Artificial breeding (AB).

The paper on artificial breeding indicates that present artificial insemination (A.I.) technology produces CRs as high as those from natural mating. Success of A.I. is dependent mainly on the quality of semen. Currently semen is prepared in liquid form (about 2 million spermatozoa per dose), frozen in straws (about 20 million spermatozoa per dose) and SEM-PAK semen (10 million spermatozoa per dose). The latter preparation is a new system which can provide semen with most of the advantages of liquid semen to areas which could not be served by a regular liquid semen service. This should benefit South Island herds. The fertilising ability of all three semen preparations is the same. Differences in fertilising ability of semen from different bulls can be minimised if sufficient data are available on the CRs previously achieved by each bull.

Although competence of A.I. technicians can be an important factor, the high standards required by the Livestock Improvement Associations and their vigilance on this aspect means that this is not a problem in N.Z.

This may not necessarily always be the case for operaters who do their own inseminations. In spite of the high competence of A.I. tochnicians their efforts will be compromised by lack of provision of suitable facilities and poor detection of oestrus. Best results from A.I. are obtained when insemination is done late in standing heat. A.I. in yearlings is successful providing the animals are well grown and they can reliably be detected in oestrus.

Causes of abortion.

The third paper in this section describes the causes of abortion, which represents a source of reproductive loss occurring between a mating programme and the expected calvings. Causes of abortion can be classified under inherited defects, congenital defects (mainly due to some viruses or to toxic chemical agents) and infectious agents. Most diagnosed abortions in N.Z. cattle arise from the latter cause, the major diseases involved being; leptospirosis, campylobacteriosis (previously known as vibriosis) and mycotic (fungal) abortion. Leptospirosis is the most commonly recorded cause of abortion (25—30% of all cattle abortions) and is significant also because of its transmission to humans. Brucellosis, listeriosis and pasteurellosis are now uncommon as causes of abortion in cattle but when outbreaks do occur, they can involve many members of a herd.

Emphasis is placed on the importance of providing well-preserved specimens for submission to Animal Health Laboratories so that diagnosis and correct remedial procedures can be carried out.

Minerals.

The remainder of this section deals with minerals.

In terms of direct effects on reproductive performance in cattle, there is little clearly demonstrated effect attributable to any of the minerals. Mineral deficiencies may be sub-clinical and interfere with nutrition, causing poor growth rates. As a result such deficiencies may manifest their effects on reproduction indirectly.

Nevertheless for a few minerals direct affects on reproduction are suspected and the metabolism of such minerals is discussed in some detail. Such minerals include calcium because the symptoms of milk fever (caused by a lowering of blood calcium levels) may mask signs of oestrus. A range of minerals have potential to impair reproduction but need to be investigated specifically to determine this. These include; phosphorus, magnesium, copper (molybdenum and sulphur interfere with copper absorption), selenium, iodine, zinc, and possibly; manganese, sodium and cobalt.

The main mineral deficiencies which have been reported in N.Z. cattle are of copper, selenium and to a lesser extent, magnesium.

Diagnosis of mineral deficiencies is often a difficult task and involves an understanding of the background to the problem, a definition of the cause and the development of a suitable test. The latter may involve analyses of samples of soils, herbages or animal specimens and will be influenced by whether the undertaking is to investigate an exisitng clinical problem or to prevent one from occurring in future. Animal Health Laboratories of M.A.F. Animal Health Division carry out such tests and maintain reference ranges for the various minerals in animal specimens. Veterinarians are kept informed of any updating of reference ranges.

A useful technique for investigating mineral deficiencies, if properly planned and executed, is a production response test where a group of supplemented animals is studied in comparison with unsupplemented herd mates.

Treatment of mineral deficiencies usually takes the form of administration of short acting preparations of the mineral whereas prevention often involves long-term supplementation such as inclusion of minerals in topdressing mixtures.

FACTORS AFFECTING REPRODUCTIVE PERFORMANCE IN THE DAIRY COW

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Introduction

The seasonal nature of dairy farming in N.Z. facilitates the most effective and economic use of pasture dry matter. It is maintained by adopting management practices which achieve a seasonally concentrated calving pattern. This pattern is initiated by a concentrated breeding programme designed so that no cows in a herd are bred before a specific date. This date is chosen by the owner as being one which best allows the integration of the feed requirements of his milking animals with seasonally influenced pasture growth patterns. From the selected date onwards as many cows as possible are submitted for insemination, usually within a 4 to 6 week artificial breeding (AB) programme. Thereafter several bulls are run with the herd until the breeding programme ends, from 10 to 16 weeks after the selected starting date. Some of the cows which conceive later in this programme may subsequently be induced to calve prematurely.

The basic relationship is that within a herd a concentrated mating programme should produce a concentrated conception pattern, resulting in a concentrated calving pattern. Therefore parameters which describe 'herd fertility' must include those relating to **conception rate** (pregnancies per 100 defined inseminations) as well as those indicating the rate at which cows in the herd were submitted for insemination (**submission rate**).

Terminology

Terms used frequently when describing aspects of reproductive performance include the following.

(a) **Conception rate (CR)** is the percentage of cows in a herd that are not recorded as returning to service within 49 days of first insemination. This may also be referred to as the 49-day non-return rate (NR); and the period may be 30 — 60 days, 60 — 90 days or 90 — 120 days. In N.Z. the term conception rate is used because the statistic is supposed to reflect closely the percentage of cows conceiving to first insemination. Because records from some herds are incomplete, with some returns-to-service not being either observed or recorded, the CR usually exceeds the true pregnancy rate to first insemination. On average the difference is 2% to 5%, but this varies widely for individual herds.

(b) **Submission rate (SR)** was originally defined as the percentage of cows in a herd inseminated during the first 4 weeks of the AB programme. This period was selected because many cows have cycle lengths of slightly more than 21 days and therefore can not be expected to be detected in oestrus during the first three weeks of AB. However many herd owners and advisers now prefer to relate submission rate to this shorter period.

(c) **Pregnancy rate (PR)** is the percentage of cows in a herd which are confirmed pregnant and which conceived during a specified period (e.g. pregnancy rate to AB, irrespective of whether conception was to

the first or a subsequent insemination).
(d) **Empty rate (MT)** is the percentage of cows in a herd which are not pregnant at the time when drying off or culling occurs. Some of these cows may have conceived to AB or a herd sire but subsequently aborted during early pregnancy. It is commonly accepted as the parameter which reflects a herd's level of fertility or infertility. The average MT in N.Z. dairy herds is less than 6%.
(e) **Return interval** is the time in days between consecutive inseminations and/or matings for an individual animal. A normal return interval is between 18 and 24 days. This is the usual range for the lengths of oestrous cycles in normally cycling cows. A short return interval is less than 18 days and a long return interval is more than 24 days. The proportional distribution of return intervals among these three categories (short, normal, long) can be used to indicate the possible nature of a fertility problem.
(f) **Gestation length** is the period of a normal pregnancy. In the common breeds of dairy cattle in N.Z. the average gestation length is 282 days, with a normal range being 18 days (S.D. = ±4.5). It is influenced by sex of calf, age or parity of dam, season, year, breed of sire and sire within breed.
(g) **Calving interval (CI)** is the average period between consecutive calvings of individual cows within a herd. While it is widely used in many countries with year-round calving as an index of a herd's reproductive performance, it is of little value in N.Z. (see Hughes, this publication). The CI in N.Z. is 364 days (12 months) compared with 395 days in U.S.A. (13 months) and 405 days in the U.K. (13.5 months).

Submission Rate (SR) and Conception Rate (CR)

In a well managed herd at least 80% of the herd should be inseminated during the first 3 weeks of the AB programme and 60% to 65% of these cows should conceive to the first insemination. Under these conditions, half of the cows retained in the herd for the following season should calve within 12 to 15 days of the date selected as the planned start of calving.

The CR can be influenced by some factors beyond the herd owner's control (e.g. semen quality, inseminator competence) but the SR is solely the herd owner's responsibility. In addition the SR requires constant daily attention from the herd owner, but the CR cannot reasonably be estimated until the AB programme has been in progress for at least 4 weeks. Therefore a herd owner should concentrate his efforts on achieving a high SR. This is because a high SR is essential if the herd is to have a concentrated calving pattern and it will minimise the effects of an unexpectedly low CR on the calving pattern.

Although some factors are of differing importance to SR and CR, the two most important factors for SR are also the two most important for CR. These two factors are;
(a) oestrous detection, and
(b) calving pattern, through its effect of the on the interval between

calving and the start of the AB programme.

Clearly, oestrous detection is of critical importance to SR, because cows which may be in oestrus and are not detected during the first 3 or 4 weeks of AB will not usually be in oestrus again for a further 3 weeks. An error in diagnosis will mean that a non-oestrous cow is inseminated. This error will not reduce the SR but will naturally reduce CR as that cow will not conceive. It would be expected to return to service after a short return interval.

The calving pattern can depress SR and CR if there is a high or low percentage of late calving cows. These cows either will not have recommenced cycling by the end of the first 3 or 4 weeks of AB or will be inseminated at the first oestrus after calving. If a herd has a high proportion of non-cycling cows, then a high SR cannot be achieved. This situation also may mean that many herd mates were inseminated at their first post-partum oestrus and would therefore have a CR around 7% lower than cows inseminated at their second or subsequent post-partum oestrus.

An additional effect on CR is that cows inseminated within 40 days of calving have a CR almost 20% lower than cows inseminated more than 40 days after calving. Therefore a spread calving pattern tends to be repetitive. This type of pattern commonly produces a low SR and below-average CR which then causes a spread calving pattern in the following season.

Other Factors Influencing SR

Nutrition can influence SR mainly through its effect on the post-partum interval to first oestrus. Although each unit increase in condition score at calving will reduce this interval by 4 to 6 days, increasing post-partum feed intake by 3 kg DM per day also will reduce the interval by 3 to 4 days. Well fed cows calving in good condition should cycle around 35 to 40 days after calving. Thin, poorly fed cows will cycle, on average, over 50 days after calving but with much variation around this average. It is important to recognise that better fed cows will produce more milk and cycle sooner. Level of production does not have a major effect on SR.

Younger cows have a longer interval from calving to first oestrus and Friesians have a longer interval than Jerseys. Dystocia, twinning and retained foetal membranes all extend this interval. However, while these factors may be important influences on the interval to first oestrus for individual cows, they will only influence the SR if a high proportion of cows in a herd fall within these categories.

Other Factors Influencing CR

Younger cows tend to have lower CRs mainly because of a longer post-partum interval to first oestrus. They also have a higher incidence of genuine short oestrous cycles of 8 to 12 days duration. In contrast, old cows (>9yrs) have a lower CR because of a higher incidence of repeat breeders and early embryonic death. Jersey cows also have a higher incidence of these phenomena than do Friesians or Friesian-Jersey cross-breeds. However, condition score at calving does not affect CR unless the animals are very fat, in which case CR is depressed.

CRs vary between years and between seasons within a year. This source of variation primarily reflects differences in nutrition, although length of daylight also may be involved. Although the intensity of oestrous behaviour does vary between cows, its effect on CR appears to be related more to the frequency of errors in diagnosis than to fertility.

Errors in diagnosis affect CR in two ways. First, a non- oestrous insemination cannot produce a conception and must therefore reduce CR. Secondly, a non-oestrous second insemination made within 3 weeks of an oestrous first insemination can halve the chances of a successful conception being maintained. A non-oestrous second insemination can 'disrupt' an establishing pregnancy. The reverse situation does not appear to have any adverse effects. That is, a non-oestrous first insemination does not prejudice the chances of conception to an oestrous second insemnation.

It is preferable for a herd owner to interpret liberally symptoms of oestrus, at least for first inseminations. While this may mean the CR is slightly reduced because of some errors in the diagnosis of oestrus, it also will mean that cows showing less obvious symptoms, but nonetheless in oestrus, will be inseminated. If this element of uncertainty is noted, then the error will be rectified when the cow in question is next detected in oestrus.

An important factor influencing **recorded** CRs is the reliability and completeness of the return data. If no records are maintained by the herd owner after a short AB programme, then that herd will have a recorded CR which bears little relevance to the actual CR. In extensive field trials conducted in herds with above average levels of production and with a high level of accuracy in detecting oestrus, the pregnancy rate to first insemination has remained at around 65% . This is relatively high by international standards. About 3% of these pregnancies will be lost between 2 and 6 months of gestation and the overall herd MT rate will be around 6% . Although CRs decline slightly with increasing herd size, most of this decline is due to a compensatory increase in the incidence of short return intervals.

This appears to reflect a higher incidence of errors in oestrous detection in larger herds, possibly due to identification problems or because less-experienced staff may be making the diagnoses. It does not reflect possible stress among cows in larger herds.

Finally, cows which have had dystocia or retained foetal membranes have reduced CRs and may also have a higher incidence of embryonic mortality.

Young Stock Breeding Management

Most maiden heifers are naturally mated from 9 months before their herd's planned start of calving for the subsequent season. They will usually be between 13 and 15 months of age. If they have been reared adequately, particularly in terms of mineral supplementation and parasite control, almost all heifers should be cycling regularly when mating commences. However, recent results following oestrous synchronisation of groups of heifers in commercial herds have been unsatisfactory because many of the heifers have not reached puberty. It is possible that greater emphasis needs to be placed on the level of feeding during the winter preceding first mating. This is especially so in herds where heifer mating commences up to 2 weeks before mating of the main herd, to allow first calving heifers a longer average interval from calving to the start of the post calving AB programme.

General Conclusions

A herd owner's objective of maintaining a seasonally concentrated calving pattern will be facilitated if he adopts management practices which produce high per cow production and maximise the proportion of cows in the herd which have commenced cycling before the start of the AB programme. Once this programme starts, emphasis must be placed on efficient oestrous detection to achieve a high SR. If these objectives are achieved, then an adequate CR should be obtained unless reduced by factors beyond the herd owner's control. If complete breeding records are maintained then factors which may have contributed to an unsatisfactory CR can be investigated.

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ARTIFICIAL BREEDING IN DAIRY COW REPRODUCTION

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Introduction

Artificial breeding (AB) includes the transfer of both ova and spermatozoa. Discussion in this paper will be limited to artificial insemination of spermatozoa.

Artificial insemination (A.I.) is now well established; approximately 150 million or 25 percent of the world cattle population being artificially bred. In N.Z. 85 percent of dairy farmers in 1982 used AB and 70 percent of the national dairy herd excluding first calvers were artificially inseminated.

In general terms, assuming semen is produced by competent AB organisations and artificial insemination technicians are properly trained and supervised, dairy farmers can expect on average the same in-calf rate using an AB programme as natural mating.

AB utilises what appears to be one of the few wasteful processes in nature. A bull produces approximately 10 000 million spermatozoa per ejaculate and yet only one spermatozoon is required to fertilise the egg. Last spring the top five Jersey and the top five Friesian Dairy Board bulls mated over 1 million cow The same bulls used under natural mating would mate only approximately 500 cows. In practical terms AB, used properly, allows every dairy farmer in N.Z. to get access to the highest breeding index (BI), high reliability bulls. Just as importantly, the high costs of selecting these bulls ($150 000 each) is spread widely so that the actual cost to the individual farmer is no greater than many natural mating programmes using unproven bulls.

Factors that dairy farmers must consider if they are to ensure high reproductive performance from an AB programme are; herd fertility, mating management, semen quality, A.I. technician competency, facilities for A.I., timing of A.I., and special requirements for yearlings.

Herd Fertility

The important aspects of herd fertility are discussed by Macmillan (earlier in this publication).

Mating Management

Oestrous detection is covered by Macmillan (earlier in this publication) and other aspects of mating management are described later in this publication (Macmillan, Rhodes).

Semen Quality

In N.Z. there are three different semen technologies in use: deep frozen semen, liquid semen and SEM-PAK semen.

Liquid semen.

More than two thirds of the total inseminations in N.Z. are with liquid semen maintained at ambient temperature provided by the N.Z. Dairy Board's Newstead AB Centre. Liquid semen maintains its fertilising ability for three days after processing assuming the semen is kept in an insulated container (10°C to 20°C), away from direct sunlight and the glass test-tubes containing this semen are not opened until the day of use. The dose rate of liquid semen is generally 2 million spermatozoa, however, an individual bull's semen may be diluted to as low as 1.5 million spermatozoa per dose or as high as 5 million.

Frozen semen.

The majority of the balance of inseminations in N.Z. are made with semen that is processed in plastic 0.25 ml straws, frozen and stored in liquid nitrogen. All semen processed by Ambreed, Guthreys and N.Z. Sire Services and approximately 25 percent of N.Z. Dairy Board semen is processed in a frozen form. The dose rate of deep frozen semen varies between organisations but is usapproximately 20 million (range 10 to 40 million) spermatozoa per straw. The main advantage of frozen semen is its long shelf life. As long as it is kept in liquid nitrogen there is virtually no deterioration in semen quality. Semen quality is affected however, if straws are put back into liquid nitrogen after exposure, even for a few seconds, to ambient temperature.

Frozen semen rapidly loses its fertilising capacity after thawing. In general terms frozen semen should be used immediately after thawing. However, frozen semen thawed in water at ambient temperature will retain its fertilising ability for approximately 15 minutes. While some bulls' spermatozoa will be starting to die off after 15 minutes, other bulls' semen will retain its maximum fertilising capacity for 30 minutes or more.

SEM-PAK semen.

A relatively new unique semen processing system to the N.Z. Dairy Board which combines some of the advantages of liquid and deep frozen semen technologies. SEM-PAK has two components. 10 doses of semen at 10 million spermatozoa per dose are packaged into a 0.25 ml straw and frozen and stored in liquid nitrogen. The second component is 5 ml of diluent which is similar to the Dairy Board liquid semen diluent. This diluent is packaged in 10 ml plastic test- tubes and frozen and kept in a domestic deep freeze. The technician prior to an AB round, thaws the diluent and semen and when both are at ambient tthe semen into the diluent. The recombined semen is then used during the day as normal liquid semen. This system has the advantage over liquid semen in that it has a long shelf life and the advantage over frozen semen of a relatively low dose rate. It has a further advantage over frozen semen in that it can be used for some hours after thawing without loss of fertility. The SEM-PAK system has obvious advantages in areas where it is uneconomical or impractical for a regular liquid semen service. Last year approximately 25 percent of the South Island liquid semen service inseminations was made with the SEM-PAK system. This year it is anticipated that this will increase to over 50 percent.

Fertilising ability of liquid, deep frozen and SEM-PAK semen.

One of the main advantages of A.I. over natural mating is that there is continuous surveillance of semen quality. Every batch of semen processed in N.Z. from all AB centres is evaluated before and after processing. Conversely, with natural mating few bulls are tested prior to mating and in most cases problem bulls are not detected until well into the breeding season.

In general terms the fertilising ability of N.Z. Dairy Board liquid, frozen and SEM-PAK semen is the same.

Up until recently liquid semen conception rate ran ahead of deep freeze conception rates. However, for the last three years the conception rate of frozDairy Board has run slightly ahead of liquid semen used under the same conditions.

Although laboratory semen quality assessments rule out the 'disaster' bulls, there is still quite a large range in conception rates of bulls with similar semen quality. Many studies show that no more than 30 percent of the variation in conception rate of bulls standing at A.I. studs can be accounted for by laboratory tests. This means that it is essential if AB organisations are to provide a high quality conception rate service, not only must they have high laboratory quality control standards but they must also have a field monitoring conception rate system.

Not only must they have the systems in place, but bulls must be culled ruthlessly on semen quality or conception rate data.

The average conception rate of semen processed by competent AB organisations that have good quality control procedures and comprehensive monitoring of bulls' conception rates in the field should be similar. For example, there is practically no difference in conception rate between N.Z. Dairy Board processed frozen semen and semen imported by the Board from reputable organisations in the U.K. and Canada. Conversely, semen inseminated by the same technicians from sources other than the above has run routinely 5 percent behind Dairy Board processed semen over the last four years.

Breed differences in semen quality.

There is no good evidence of inherent differences in the fertilising capacity of semen used for A.I. from the main dairy breeds used in N.Z.

Bull differences in fertility.

As mentioned above, A automatically culls out the real problem bulls. However, there are still significant differences in fertility of individual bulls used in the A.I. industry in N.Z.

Individual bulls are known to have conception rates 10 percent or more below average. Most of these bulls are standing at AB centres where there is either relatively poor field monitoring systems for conception rate or where organisations are prepared to market the bulls with significantly below average conception rates.

In organisations that have a good field recording system in operation and where bulls are culled ruthlessly on conception rate, the variation in fertility between individual bulls is relatively small. For example, in 1982 when over 1 million inseminations were made with Dairy Board liquid semen, the lowest conception rate bull that was used widely had a conception rate only 3 percent below average. A similar situation exists with deep frozen semen processed from N.Z. Dairy Board bulls. Conversely, privately owned bulls processed by the Board with the same semen quality standards but without back-upconception rate.

The conception rate of individual bulls is remarkably repeatable from year to year and within batches of a particular year. Evidence in N.Z. and overseas suggests that the differences in fertilising capacity of individual A.I. bulls lies in their different ability to actually fertilise eggs rather than on differing bull effects on embryonic mortality.

The differing fertilising abilities of bulls is closely related to the *in utero* survival of the individual bull's spermatozoa. That is, bulls with high fertilising ability have semen that lasts longer in the reproductive tract compared to that of bulls with lower fertility.

A.I. Technician Competency

The main objective of the A.I. technician is to insert semen, without affecting its quality, into the body of the uterus of a healthy cow in a gentle and hygienic manner. It is important to remember that it is not the technician's role to ascertain if an individual cow is in season or if the timing of the insemination is correct.

Most physically able people if given sufficient tuition can be trained to be competent inseminators. The Livestock Improvement Associations throughout N.Z. train approximately 200 technicians a year, each technician learning on at least 200 different cows. Approximately half of these cows are slaughterhouse animals and the balance are those in farmers' herds. By the end of this extensive training programme only about 10 percent of technicians are found not to be competent inseminators.

However, technicians who appear to have similar abilities as inseminators have varying abilities in actually getting cows in calf. As with bulls the only final way to assess the competency of a technician is through his/her ability to get a significant proportion of cows mated in calf. Technicians who do not have a satisfactory conception rate should have their licences terminated or be subject to re-training programmes. Livestock Improvement Association's technicians in N.Z. who have a non return rate (on an 18 to 24 day basis) of more than 10 percentage points below average are not re-employed. Technicians with a non return rate of 5 to 10 percent below average are either not re-employed or are subject to a re-training programme. The most common fault with these latter technicians is in pipette placement. The separation of the uterus into two horns starts very close to the cervix and it is essential that semen is not released past this separation. In practical terms this means that the pipette should just enter the uterus. Simply pushing the A.I. instrument two to three centimetres into the uterus and withdrawing it to the correct position will result in a conception rate drop of approximately 5 percent. With intense training, good supervision and monitoring of conception rates, AB organisations can maintain a high overall A.I. technician standard of competence.

Importantly from the individual farmers' point of view these high standards result in remarkably small numbers of below average conception rate technicians. For example, in 1982 of the 600 technicians employed by Livestock Improvement Associations throughout the country, who had 500 or more first inseminations included in their results, only 2 percent had a conception rate of more than 10 percent below average on an 18 to 24 day non return rate basis. 12 of the 13 technicians involved had conception rates in the minus 10% to minus 15% range and only one technician could be classified as a real disaster with 60 percent of cows mated returning in the 18 to 24 day period. In the South Island Livestock Improvement Association in 1982, the lowest technician conception rate on an 18 to 24 day non return rate basis was 69 percent compared with the Association average of 79.5 percent. These figures are even more remarkable when consideration is given to the fact that all of these technicians operate for only 6 to 7 weeks during the spring and are mainly part-time employees.

Evidence from overseas suggests that conception rates of farmers who inseminate their own cows (D.I.Y.) is approximately 10 percent behind professional technicians. Limited information from Dairy Board statistics suggests that the gap may be not so wide in N.Z.

However, most D.I.Y. operators in these results were either farmers who had previously been technicians or at least passed through an intensive training school run by Livestock Improvement Associations. A cross section of D.I.Y. operators in N.Z. show that some have such bad results that they go back to a professional A.I. service. Although there is limited evidence, there is probably a much wider range in D.I.Y. conception rates compared with a fully trained, supervised and conception rate monitored technician service.

Facilities for A.I.

To get good fertility results from an A.I. programme farmers must not only present fertile cows in the right stage of oestrus to the technician, but the cows must be presented in a reasonably quiet and relaxed state and facilities derestricted while still allowing clear access to the rear of each animal. It is important that the A.I. technician can stand comfortably behind the cow at th e same level as the animal. A pamphlet is being prepared for farmers on A.I. facilities and this will be available shortly through the South Island Livestock Improvement Association.

Timing of Insemination

True oestrus (standing heat) is the short period when the cow accepts service from a bull. The signs and duration of heat are quite variable, for example, cows can be in true oestrus for anything from 2 to 24 hours (average 18 hours). Ovulation (shedding of the egg from the ovary) also occurs at variable times in relation to oestrus. Ovulation can occur as early as 2 hours before the end of standing heat to 28 hours after the end of standing heat. The majority of eggs are shed 8 to 16 hours (average 12 hours) after the end of standing heat. The egg remains fertile for only a short period perhaps not more than 6 hours after ovulation. In contrast spermatozoa can retain their fertility for up to 24 hours after A.I.

Spermatozoa from bulls of high fertility last longer *in utero* than spermatozoa of bulls with low fertility. A trial with N.Z. Dairy Board sires showed that the conception rate of above average fertility sires was 6 percent higher than below average sires when mated to cows in late oestrus. (Late oestrus was defined as those cows that were seen in standing heat on one day and were inseminated the following morning.) However, when the same sires were mated to cows in early oestrus, that is, cows seen in standing heat for the first time in the morning and mated that same morning, the conception rate difference was a massive 15 percent in favour of the above average sires.

Taking into consideration the above and other research into the conception rate of semen inseminated at various times it is clear that the highest conception rates are obtained when cows are inseminated during late standing heat. The next highest conception rate period is when cows are inseminated immediately after standing oestrus followed by cows inseminated at mid-oestrus. The worst situation is when cows are inseminated in early oestrus.

Yearling A.I.

Increasing numbers of farmers are mating yearlings artifically. A survey in 1982 of AB users showed 11 percent of farmers inseminating at least some yearlings. A successful yearling A.I. programme is dependent upon;

(a) well grown healthy yearlings,
(b) good facilities for restraining yearlings,
(c) farmers' assistance at the time of insemination,
(d) quiet yearlings that are used to being handled, and
(e) an efficient method of oestrous detection, ideally involving the use of tail paint.

If the above factors are all operational a yearling AB programme should be equally as successful as the AB programme in the adult herd. Most of the disastrous AB programmes with yearlings have involved oestrous synchronisation. The most common problem is trying to synchronise heifers that in fact are not cycling. Problems also occur with a fixed-time insemination regime. Conversely most of the A.I. programmes involving yearlings submitted naturally to A.I. have been reasonably successful.

One of the real advantages of AB of yearlings from a reproductive performance view point is that it allows farmers to mate Friesian sires with known ease of calving data to Freisian yearlings. A recent survey of farmers who used the 'easy calving' package of N.Z. Dairy Board Friesian sires over Friesian yearlings showed that calving was not a significant problem.

Summary

The factors a farmer must consider, and which to a greater or lesser degree are under his control, when undertaking an A.I. programme are the following.

(a) The health and reproductive status of his herd.

(b) The ability to detect oestrus, to mate cows at the right time and to have good general mating management techniques.

(c) The dairy shed facilities that are required to optimise the comfort and convenience of the cows to be mated and the technician.

(d) Semen quality control procedures of semen production centres.

(e) The training standards or known ability of the A.I. technician.

DISEASES CAUSING CATTLE ABORTIONS

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Introduction

A practical definition of abortion is 'the death and expulsion of the foetus at any time during pregnancy or the expulsion of a living foetus before it reaches a viable age'.

Causes of abortion will be discussed under the following headings; inherited defects, congenital defects, and infectious agents.

This paper is concerned primarily with the infectious agents as these are the major abortifacients (abortion producing agents). For completeness, examples of the other categories will be mentioned.

Pathogenesis

The physiological pathways leading to abortion differ according to the type of agent. Viral infections such as bovine viral diarrhoea (B.V.D.) and rinderpest cause lymphatic tissue depression and therefore reduce the immunoresponsiveness of the host. Reggiardo and Kaeberle (1981) showed that the pathogenesis of the immunodeficiency caused by B.V.D. involved impaired function of polymorphonuclear cells (a certain type of white blood cell).

The effects of stress, whether psychological, physical, environmental or nutritional in the form of protein-calorie malnutrition, are identified as means of suppressing immunological responsiveness.

Immunosuppression is also caused by; toxins from bracken fern, tetrachloroethylene, irradiation, 2,4,5-T residues, D.D.T., aflatoxins and heavy metals.

Inherited Defects

Genetic defects exert an influence in several ways. Usually it is a structural defect, leading to congenital deformity or premature degeneration. These inherited defects may increase foetal susceptibility to relatively mild pathogens.

Inherited diseases generally are difficult to diagnose and because of this it is important to gain as much information as possible to establish whether the disease is inherited or acquired. The clinical picture and history, cytogenetic markers, specific biochemical reactions and epidemiological data can all contribute.

In bulls, Klinefelter's syndrome, i.e. where more than one X chromosome is present in the somatic cells, leads to foetal deformation, death and absorption.

Inherited goitre is due to a defect in the synthesis of thyroid stimulating hormone (TSH), giving rise to thyroid hyperplasia (goitre).

Congenital Defects

Congenital defects are commonly caused by a teratogenic agent (an agent producing physical defects in the foetus). This may be a chemical, a viral infection, a nutritional deficiency, a toxic product from bacteria, or hypoxia (lowering of oxygen level). Congenital defects may not cause abortion but they can bring about calf death due to the inability to survive after the umbilical cord is severed or causes obstruction during parturition, with subsequent foetal retention and death.

Examples of the more important teratogenic agents are given below.

(a) Viral teratogens.

The B.V.D. virus can cause cerebellar hypoplasia (defective brain development) in calves, optical defects, brachygnathia (abnormally short lower jaw), abortion, still birth and foetal mummification.

The akabane virus which may cause arthrogryposis (permanent flexure of a joint) and/or hydroencephaly (abnormal fluid within the brain - 'water on the brain').

(b) Toxic agents.

Irradiation with β or δ rays can cause foetal malformations and death.

Nitrate/nitrite poisoning brings about the conversion of haemoglobin to methaemoglobin, thus reducing the oxygen carrying capacity of the blood. Because of the hypoxia the foetus may die and abort. High levels of nitrate are present in mangels, kale regrowth, turnip tops and some rye-grasses, e.g. Tama and Ariki — at certain times of the year (Clarke and Clarke, 1967).

Ergot from the fungus *Claviceps purpurea* acts as a vasoconstrictor (constricts blood vessels) which causes hypoxia followed by foetal death and expulsion.

Abortion due to wilted macrocarpa (*Cupressus macrocarpa*) is a well-recognised clinical entity (MacDonald, 1956). The lesions of cerebral leucomalacia (softening of certain areas of the brain) in the foetus, associated with macrocarpa abortion in cattle, have been described by Mason (1974).

Pine needles also have been incriminated as causes of abortion (Knowles and Dewes, 1980) but the toxic agent has not been identified.

(c) Nutritional deficiencies.

Iodine. Lack of iodine or a high intake of brassica crops containing goitrogenic compounds can cause an enlargement of the thyroid gland — goitre.

Magnesium. Magnesium deficiency leads to limb deformities in calves.

Malnutrition. Simple inanition (lack of any foodstuff or water) or a deficiency of protein can lead to abortion or still birth.

Vitamin A. Vitamin A deficiency has many untoward effects. One of these is impairement of endometrial function which produces infertility or resorption of the foetus as clinical findings. Other effects are blindness and structural deformities occurring in the calves. In N.Z. cattle, vitamin A deficiency is unlikely to be of significance.

Infectious Agents

Infectious agents are by far the most important abortifacients. Most are well-recognised agents and relatively easy to identify. However if specimens of aborted material are of poor quality, laboratories have a difficult task isolating the causal agent(s).

TABLE 1.
Diseases and disease agents causing abortion in N.Z. cattle.

Disease	Percentage of abortions	Stage of gestation
	OF MAJOR IMPORTANCE	
leptospirosis	25 — 30%	after 6 months
campylobacteriosis (previously called vibriosis)	less than 5%	5 — 6 months
mycotic abortion	5 — 7%	3 — 7 months
	OF MINOR IMPORTANCE	
bovine viral diarrhoea (B.V.D.)		
infectious bovine rhinotracheitis/infectious pustular vaginitis (I.B.R./I.P.V.)		
brucellosis		
Pasteurella multocida		
sarcocystis		
rotavirus		
severe debilitating disease		
listeriosis		
Corynebacterium pyogenes		
salmonellosis		
trichomoniasis		

As a result of the brucella eradication scheme, artificial insemination (A.I.) and better hygiene, the previous order of importance has changed. For example, brucella abortions were probably the most important but as at January 1984 there were no recorded infected herds in the South Island and only 78 in the North Island. Leptospiral abortions are now probably the most common of all abortions in N.Z. cattle. Table 1 lists infectious agents isolated in specimens submitted from cases of abortion in N.Z. cattle. Leptospirosis, campylobacteriosis (previously called vibriosis) and mycotic (fungal) abortion are, in my view, the most common of these diseases. Brucellosis, listeriosis and pasteurellosis are more likely to be involved in abortion storms, so when an outbreak of one of these occurs on a farm a large number of pregnant animals may be involved. Nevertheless, as causes of abortions in this country, these diseases are of lesser significance than leptospirosis, campylobacteriosis or the mycoses.

Leptospirosis.

Of the *Leptospirosis interrogans* serotypes, *pomona* and *hardjo* are the two most important as causes of abortion in N.Z. cattle.

Abortions caused by *L. pomona* usually occur in the latter half of pregnancy. The normal host for *L. pomona* is the pig (Blood *et al.*, 1983) but it can affect many animal species. In cattle the disease caused by this agent occurs in three forms; acute, sub acute and chronic. In the acute form icterus (jaundice), a swollen yellowish liver and petechiation (very small haemorrhages) are the principal gross findings. Haemolytic anaemia accounts for the haemoglobinuria (red water) and partially contributes to the icterus and hepatic lesions. The abortion is not associated with specific lesions in the placenta or foetus, but is due to the systemic responses to hypoxia. In the sub acute form abortion may occur in 3 to 4 weeks post infection and the clinical signs are less severe than in the acute form. The chronic form of the disease is manifested by abortion. Severe abortion storms can occur when animals of the same age are all infected at the same time.

Cattle are the normal hosts for *L. hardjo* (Blood *et al.*, 1983) and it occurs only in pregnant or lactating cows. This is because growth of the organism is restricted to the pregnant uterus and the lactating mammary gland. There is a sudden onset of fever, anorexia, immobility and agalactia (failure to secrete milk). The udder may become flabby but with no heat or pain detectable. Abortion may occur several weeks after infection. Where the disease is endemic only the heifers become newly infected (Hellstrom, 1982) and may abort. Towards the end of 1983 a serological survey was conducted by the N.Z. Ministry of Agriculture and Fisheries (C.J. Boland, pers. comm.) to determine the prevalence of *L. hardjo* in dairy cattle in Canterbury, Otago and Southland. It was found that 61%, 95% and 78% of herds, respectively, were infected according to the criteria used.

Campylobacteriosis (previously called **vibriosis**).

Abortions from campylobacteriosis (*Campylobacter fetus*) are usually of low incidence (up to 5%) but on occasions the incidence may rise to 20% (Blood *et al.*, 1983). Abortions occur in the 5th to 6th month of gestation.

C. fetus causes petechiation, localised avascularity (reduction in blood) and oedema (swelling) of the placenta. The infection and its products kill the foetus which is then expelled. This may occur as quickly as two days after infection. The foetal liver has foci of necrosis (death of tissue) a few millimetres in diameter and perivascular cuffing with neutrophils and eosinophils (types of white blood cells).

Campylobacteriosis is most unusual in dairy cattle but occurs more commonly in beef cattle.

Mycoses.

In N.Z. two species of fungi are the main causes of mycotic abortion. These are *Aspergillus fumigatus* and *Mortierella wolfii*. The latter fungus is not found in the South Island to my knowledge but occurs in the North Island, mainly in the Waikato area.

When mycotic placentitis occurs, it is usually as a result of feeding cattle mouldy hay. It is considered that the fungal spores are disseminated via the circulation and many of them lodge in the placentomes (attatchment points between dam and foetus). Incubation period for this infection is thought to be one to two months. The hyphae grow in the vascularised areas and their growth may eventually lead to hypoxia. Although fungi can be isolated from foetal organs it is unusual for lesions to occur in foetuses.

Specimens Required for a Diagnosis

Diagnosis of abortion in dairy cattle is usually easier than for beef cattle. In both, the dead foetus is rarely expelled from the uterus immediately and thus degeneration of the tissues occurs. The autolysis may affect the causative organism so that when tissue specimens are sent to the laboratories for a diagnosis it can be very difficult to grow the organisms.

The specimens required for diagnostic examination vary a little according to which organism is suspected. Foetal lung and liver samples (formalin-fixed and fresh) and foetal stomach contents are the most useful samples. Placental fluid, fixed and fresh cotyledons and serum from the dam are also desirable.

Conclusion

In summary, it can be seen that leptospirosis is the most common disease diagnosed as a cause of abortion in N.Z. cattle. However, many abortions are undiagnosed and it is important that both the farmer and the veterinarian make certain that the fullest range of specimens is submitted, in the best state of preservation possible, to the Animal Health Laboratories.

The major role of infectious agents in bovine abortions means that careful consideration should be given to control measures and the development of prevention programmes. Both control and prevention will depend on accurate diagnoses being made.

The development of vaccines against the leptospiral serovars has provided an effective tool in the management of this condition. Not only will the use of these vaccines reduce the incidence in cattle but it will also reduce the danger of transmission to humans.

Finally it is essential for the cattle industry that close liaison with the veterinary profession is established by the farmer and maintained for successful elucidation and control of this problem.

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MINERAL METABOLISM AND REPRODUCTION IN CATTLE

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Introduction

Reproductive problems are complex and may result from poor husbandry, disease and in some cases mineral deficiencies. The potential significance of mineral status in impaired cow fertility requires an understanding and acceptance of the concept that the effects of mineral deficiency may operate through a number of mechanisms.

(a) The first signs of a mineral deficiency are generally non-specific and are manifested sub-clinically in poor growth. Specific signs of deficiency become apparent only when animals are severely deficient. Young animals are particularly sensitive to mineral deficiencies. Such affected animals tend to be mated at the lower range of weight-for-age and remain sub-optimal in weight throughout their lifetime. They may be particularly susceptible to low weight-induced problems during breeding and in early lactation.

(b) Secondly, marginal deficiencies may depress dry matter intake. If this occurs during lactation body weight loss is exacerbated and, as an indirect consequence, re-breeding problems may increase.

(c) Thirdly, biochemical reactions concerned with specific physiological processes in reproduction may be dependent upon specific mineral nutrients and a direct effect of mineral deficiency may occur; for example dopamine β-hydroxylase is a copper-dependent enzyme involved in the synthesis of hypothalamic transmitter substances important in the control of ovulation.

(d) Finally, disease agents could reduce the animal's ability to absorb its requirement and thus contribute to mineral disorders. These changes are often suspected to occur in gastrointestinal parasitism, because of the ubiquitous nature of nematode parasites and their inevitable association with ill-thrift syndromes in which a mineral deficiency is suspected; but there is surprisingly little incontrovertable evidence that this is, in fact, the case. There is strong evidence for impairment of phosphorus absorption and for low phosphorus status in parasitism of the small intestine in sheep (Sykes, 1983) and for reduction in copper status in cattle infested with the large intestinal parasite *Bunostomum phlebotomum* (Bremner, 1959). The latter species of parasite is not, however, of major importance in N.Z.

The current recommendations, expressed on a dietary basis, for the major and trace mineral requirements of growing and lactating cattle are given in Table 1.

TABLE 1.
Minimum dietary mineral concentrations for maintenance of nutrient balance in growing and lactating dairy cattle (after A.R.C., 1980).

Element	Growing cattle 200kg; gaining 1.0kg/day	Growing cattle 300kg; gaining 0.8kg/day	Lactating cattle 20 — 30 1 milk/day
	g/kg DM	g/kg DM	g/kg DM
calcium (Ca)	4.4	3.0	3.2
magnesium (Mg)	1.2	1.2	1.9
phosphorus (P)	2.3	2.3	3.0
sodium* (Na)	0.6	0.5	1.2
potassium* (K)	4.4	4.4	5.8
sulphur (S)	1.8	1.8	1.8
	mg/kg DM	mg/kg DM	mg/kg DM
copper** (Cu)	8	8	10
iron (Fe)	30	30	40
cobalt (Co)	0.08	0.08	0.08
selenium (Se)	0.03	0.03	0.0
iodine*** (I)	0.5	0.5	0.5
zinc* (Zn)	25	25	2
manganese* (Mn)	25	25	25

*Limited ability for storage in animal body — see text.
**Coefficient of absorption may change this value markedly — see text.
*** 2mg/kg DM in the presence of goitrogens.

These have been calculated from the daily losses of the nutrient from the body, including milk, or deposition in the body, and knowledge of the fraction of dietary mineral likely to be absorbed. For many trace elements, however, requirement is that concentration found in practical feeding trials to be consistent with normal performance. These are only guidelines as many factors can influence the proportion absorbed (e.g. see *Fig. 2*). Pastures containing a greater mineral concentration than those given in Table 1 are unlikely, however, to be deficient.

The mineral content of pasture varies according to season, pasture species, soil type and previous fertilizer treatment. A true picture of the pasture mineral status therefore requires direct measurement of the area under investigation perhaps several times a year. Further the animal has body stores of some minerals, e.g. calcium, phosphorus and copper and these can be used without loss of production and mask a deficiency for considerable periods of time. Some minerals such as sodium and zinc, however, cannot be stored and continuous dietary supply is essential.

TABLE 2.

Conditions of greatest risk for trace element deficiencies (low Cu, Co, Se and I: high Mo) (from Cornforth, 1982).

	Cu deficiency	Co deficiency	Se deficiency	I deficiency	High Mo (induced Cu deficiency)
Season	Spring	Spring/summer	Late spring/autumn	Summer	Late winter/spring
Pasture maturity	Old	Old	—	—	Young
Pasture growth rate	Rapid	Rapid	Rapid	—	Slow
Pasture species	Grass dominance, Fescues	Fescues. cocksfoot, Timothy, Phalaris	White clover, paspalum, kikuyu	White clover, Cruciferae	Clover dominance or Yorkshire Fog, cocksfoot
Soil pH	High	High	—	High	High
Soil organic matter	High	High	High	Low	High
Soil water	Dry	Dry	Wet	—	Wet
Animal species	Calves	Lambs	Young stock	Newborn lambs	Cattle
Soil contamination	High	Low	Low	Low	High
Soil types or parent rocks (PR)	Peats, sands, podzols, shallow rendzinas, upland YB earths		Taupo and Kaharoa pumice, peats, N. podzols, gleys, S.I. YG earths, Manawatu sands, coarse acidic PR	Sands, inland S.I. areas, sedimentary PR	
Dietary interactions	High S, Fe and Mo			Goitrogens	

The diagnosis of mineral deficiencies is complex (Clark, 1983) and is discussed by Gumbrell (this publication). It is impossible in a paper such as this to deal in detail with the metabolism of each mineral. For further comprehensive information consult A.R.C. (1980), Underwood (1981) or Grace (1983).

Calcium (Ca)

Calcium is prodominantly (98%) found in the skeleton. However, ionized Ca in body fluids also has a major role in nerve conduction and muscle contraction and despite the large skeletal stores short-term problems with mobilization of Ca, coupled with low Ca absorption, can lead to nervous disorders. These are seen clinically as milk fever or hypocalcaemia which is associated with a decrease in plasma Ca levels and characterised by restlessness, inappetance, muscle tremors and collapse. While this is usually a problem of the cow just before calving there are numerous cases of hypocalcaemia recorded coincident with oestrous activity (Bach & Messervy, 1969). Such cows are less likely to be detected in heat and will tend to have long calving intervals (CI).

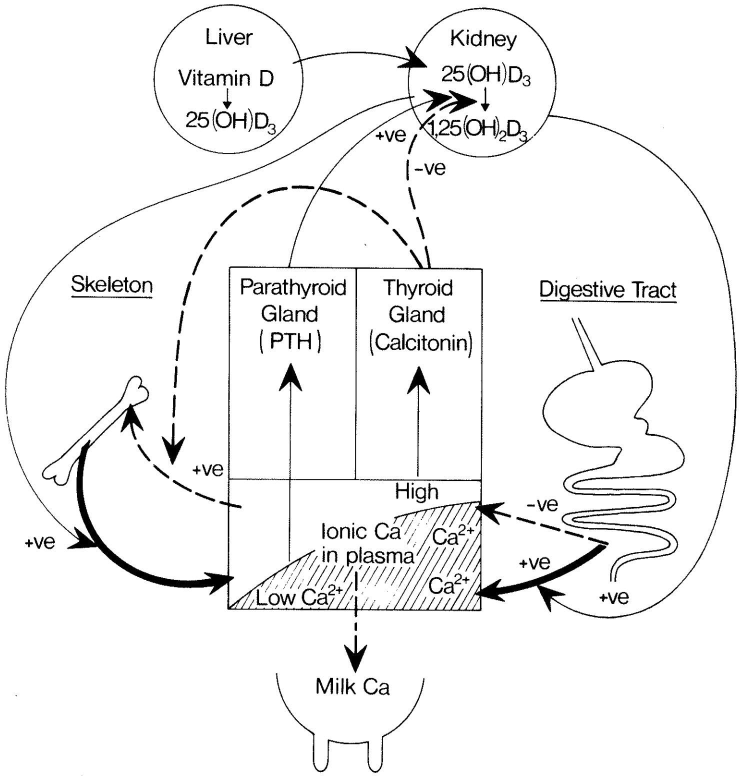

Figure 1: The mechanism of regulation of calcium absorption from the digestive tract and skeletal reserves to maintain plasma ionic calcium (Ca) concentrations. Dashed lines indicate reactions which diminish and solid lines those which enhance plasma Ca concentration. (PTH is parathyroid hormone.)

Calcium metabolism is under strict hormonal control in ruminants as demonstrated in Figure 1. Lowering of Ca in blood plasma through demand, for example, for milk production ordinarily sets in a train a series of events involving parathyroid hormone (PTH) which promote Ca absorption from the intestine and Ca resorption from the skeleton under the action of 1:25 dihydroxy cholecalciferol ($1,25(OH)_2D_3$), thus restoring plasma Ca content. The counter reaction, to prevent excessive rise of plasma Ca, is the secretion of calcitonin from the thyroid gland; this has the action of promoting the deposition of Ca in bone and inhibiting the production of $1,25(OH)_2D_3$. Ostrogens produced by the ovary at oestrus have been shown to interfere with this control and to reduce the ionized Ca content of serum, thus predisposing the animal to hypocalcaemia. This effect is not a disorder of Ca intake since it is caused hormonally. Prophylactic treatment is difficult. Culling is probably the most effective solution because it is likely to occur in the same animal again.

Phosphorus (P)

Given the dependence of pasture production in N.Z. on superphosphate application it would seem unlikely that P deficiency will present major problems for cow fertility, either for adequate growth of young stock or fertility of adult stock. Pasture content is usually between 2.0 and 4.0 g P/kg DM. Comparison with estimates of requirement (*Table 1*) suggests, however, that in some cases animals might not meet requirements for lactation from pasture and may use their body P reserves, particularly during early lactation. As with Ca large stores of P exist in the skeleton and production penalties do not appear to be incurred if these reserves are utilized; indeed there is evidence that these reserves are used rather well.

Littlejohn and Lewis (1960) offered heifers a diet containing only 1.05 g P/kg DM, less than half that generally recorded on pasture in N.Z., for two months prior to insemination and considerable reduction in blood P concentration was induced compared with animals supplemented to a dietary concentration of 2.1 g P/kg DM. No difference in fertility was observed. Further, Call *et al.* (1978) fed Hereford heifers a diet containing only 1.4 g P/kg DM for two years and found no effect on growth rate or fertility.

On the other hand Hunter (1977) observed that animals with declining serum P concentrations during the mating period had non-return rates of 46% compared with 80% in herd mates with rising P concentrations. Moreover, Scharp (1979) showed a major response of first service pregnancy rate from 36.5% to 63.2% with supplementary superphosphate in drinking water, in cows with blood P concentrations of about 40 mg P/l. The feeds concerned, however had high P content (3.9 — 5.4 g P/kg DM). Moreover, it was difficult to determine whether the response reflected a true response to P as the super-phosphate used contained considerable quantities of other essential elements including copper.

The relevance of these latter studies to N.Z., situations is difficult to assess since in some cases, pasture analyses were not reported. It would appear, however, that only if herbage P concentrations are below 2 g/kg DM would supplementation trials be worthwhile.

Magnesium (Mg)

The symptoms of Mg deficiency — nervousness, pricked ears, head held high and staring eyes, with stiff or stilted gait — are symptomatic of acute disease and the animal usually rapidly passes into convulsions, coma then death or is treated and recovers. However, a chronic form of Mg insufficiency has been found in dairy cows and is characterised by plasma Mg levels below 15 mg/l (normal range 18 — 24 mg/l). These animals are very prone to hypomagnesaemic grass tetany and may respond, in terms of production, to daily Mg supplements (Young and Rys, 1977). While there are no reports which clearly link subclinical hypomagnesaemia with infertility, it seems reasonable that this possibility should be examined more thoroughly. An indirect effect through low intake and body condition, as a result of low Mg status, may operate. The estimates of requirement given in Table 1, when compared with the normal Mg content of pastures in N.Z. (Grace, 1983), suggest that Mg deficiency is unlikely. However, we know little about absorbability of Mg in fresh herbages other than that it is generally rather low, possibly due to interference to Mg absorption by dietary factors such as high concentrations of potassium and possibly from the high protein content of pastures. In some situations the absorbability may be lower than that on which estimates in Table 1 have been based. The estimates of minimum dietary Mg concentration could then be a serious underestimate. Responses to Mg supplementation will provide the best assessment of the Mg status of the cow.

Sodium (Na)

Sodium is an important extracellular cation and is involved in maintenance of the osmotic relationships between body cells and extracellular fluids. The animal can not store Na and a continuous, adequate supply is required. Lactation poses a particularly heavy demand for Na which may be exagerated in those cows with mastitis infections where Na secretion has been suggested to increase 5-fold (Towers and Smith, 1983).

Certain pasture plants, notably lucerne, red clover, timothy and brown-top assimilate Na only poorly compared with rye-grass, prairie grass, white clover and brassicas (*Table 3*) and therefore the Na concentration in the former may range from 0.1 to 0.4 g Na/kg DM, while that of the latter would be 0.8 to 3.1 g Na/kg DM on the same soil type.

TABLE 3.
Sodium content of pasture and crop plants (from Towers and Smith, 1983).

Natrophilic	g Na/kg DM	Natrophobic	g Na/Kg DM
Perennial ryegrass	3.1	Brown top	1.0
Cocksfoot	3.2	Meadow grass	1.7
Phalaris	4.4	Tall Fescue	2.4
Prairie grass	3.4	Timothy	0.3-0.4
Yorkshire fog	1.4-4.0	Kikuyu	0.4-0.5
		Paspalum	0.4-0.6
Lotus	3.2	Lucerne	0.1-0.5
White clover	3.3	Red clover	0.4
Subterranean clover	3.5	Lupin	0.3
Choumoellier	4.1	Maize	0.1
Kale	3.7	Sudax	0.1

Other conditions predisposing to low herbage Na content, other than plant species, include free draining soils derived from pumice material. Silage making is a process notorious for Na losses which exagerate deficiency in plant material; lucerne silage being particularly low in Na.

The requirement for the lactating dairy cow is considered to be about 1.2 g Na/kg DM and for growing stock 0.5 g Na/kg DM. Sodium supplementation would seem inevitable where stock have sole access to the natrophobic group of herbages. A specific requirement for Na for reproduction does not appear to have been established but indirect effects may be expected through reduced feed intake and body condition.

Sulphur (S)

It is unlikely that, where soil deficiency of sulphur for optimum herbage growth has been corrected, a deficiency of sulphur in livestock will exist.

Copper (Cu)

Copper metabolism in ruminants is a complicated topic. The estimate of requirement in Table 1 is based on an assumption that about 4% of dietary Cu is absorbed. We know, however, from studies of Suttle and McLaughlin (1976) with semi-purified diets, that molybdenum (Mo) and sulphur interfere with absorbability of Cu by forming insoluble copper-thiomolydate complexes in the rumen, thus reducing Cu availability. The general relationships between these three minerals and their effect on absorbability of Cu are given in Figure 2. These serve only as a guide. Caution should be exercised in extrapolating these data to herbages because there is evidence that the estimates may be in error by a factor of 2 when applied to fresh or conserved herbages (Suttle, 1980). The Cu requirements for cattle are generally higher than for sheep (A.R.C., 1980).

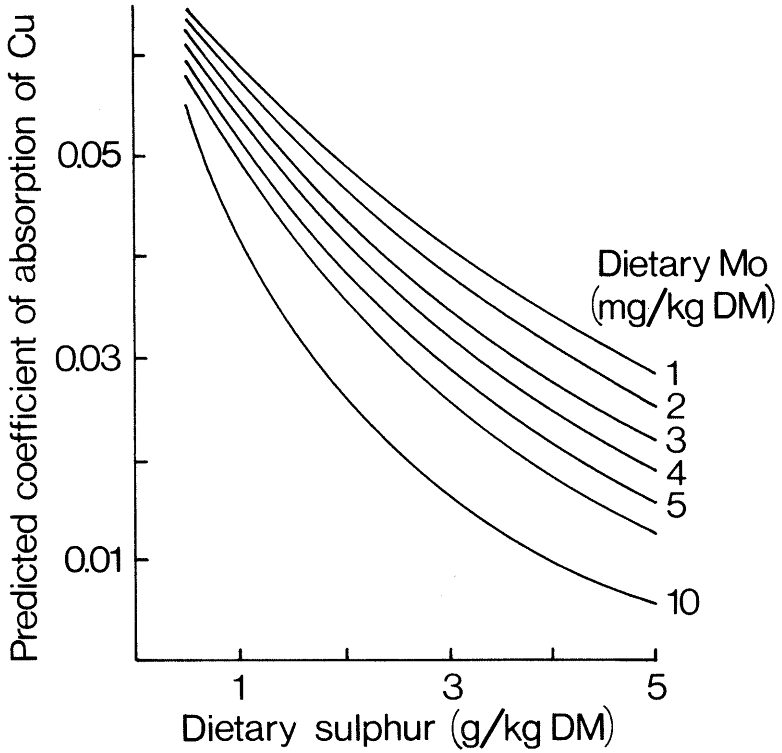

Figure 2: Effect of changing dietary molybdenum (Mo) and sulphur levels on the absorption of copper (Cu). (From A.R.C., 1980; by permission of Commonwealth Agricultural Bureaux.)

The evidence for involvement of Cu in problems of infertility is conflicting. Those studies in which response to Cu therapy has been observed have generally been uncontrolled clinical trials (Munro, 1957; Pickering, 1975; Hunter, 1977) and Cu status of animals has been poorly defined. Increases from 40% to 75% in conception rate have been reported after supplementation. In the absence of control animals and further information on actual Cu status such data must be viewed with caution, since in some studies at least, the response to supplementation in herds diagnosed as being deficient was only seen in 50% of herds treated.

Much greater reliance can be placed on controlled trials such as those of Phillippo *et al.* (1982a). In this study fertility in 17 beef herds was related to herd Cu status based on serum Cu levels within a month of the bull being put out. The results are given in Figure 3 and show that over a wide range of herd mean serum Cu concentration there was no effect on percentage of cows calving within 28 days. It should be noted that a

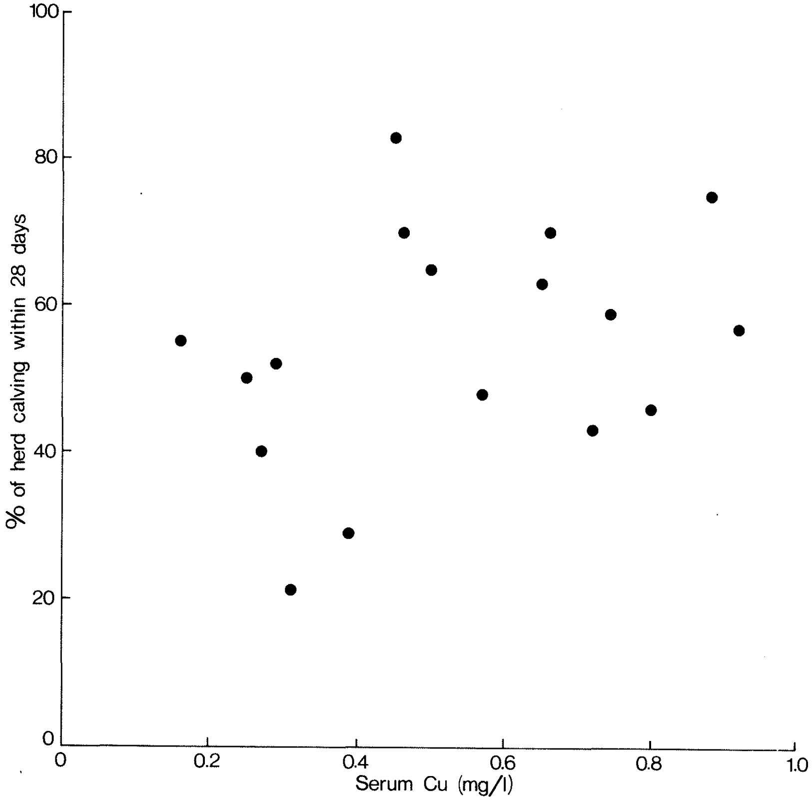

Figure 3: Relationship between mean serum copper (Cu) level and distribution of calving in beef herds. (After Phillippo *et al.*, 1982a; by permission of Cambridge University Press.)

Cu concentration of 0.5 mg/l is generally considered to be the lower limit of the range of normality.

A further study involved supplementation of cattle on four farms selected on the basis of a mean herd serum Cu concentration of less than 0.3 mg/l. Herbage Cu status was low (4.7 — 5.8 mg Cu/kg DM) and herbage contained molybdenum and sulphur at levels (1 — 3 mg Mo/kg DM; 1 — 3 g S/kg DM) which would interfere with absorbability of Cu (*Fig. 2*). Half of the cows were supplemented with a single injection of 100 mg Cu one month prior to the introduction of the bull. The results are shown in Fig. 4 and demonstrate that despite low fertility and initially very low serum Cu, elevation of serum Cu levels, in some cases into the normal range, had no effect on fertility. These data suggest that Cu requirement for reproduction is lower than for growth.

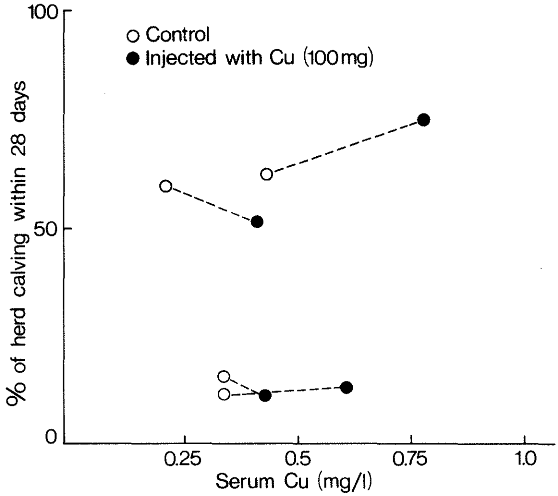

Figure 4: Effect of copper (Cu) supplementation one month prior to introduction of the bull on serum Cu concentration and fertility in four beef herds. (After Phillippo *et al.*, 1982a; by permission of Cambridge University Press.)

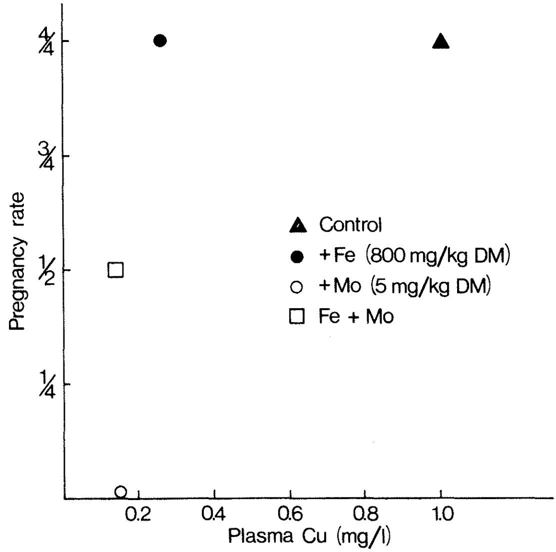

Figure 5: Effect of reduction in copper (Cu) status by iron (Fe) and molybdenum (Mo) loading of a diet containing 4 mg Cu/kg DM and 28 g sulphur/kg DM on cow fertility (n = 4 per group). (After Phillippo *et al.*, 1982b; by permission of Cambridge University Press.)

On the other hand Phillippo *et al.* (1982b) demonstrated normal pregnancy rates in cattle with low Cu status (0.23 mg Cu/l serum) induced by high intakes of iron as many occur, for example, with high soil intake. In contrast, however, very low pregnancy rates were observed in cattle with low Cu status (0.16 mg Cu/l serum) induced by dietary molybdenum excess (*Fig. 5*). This raises the question as to whether poor fertility associated with low Cu status is, in fact, due to low Cu status *per se* or to molybdenum excess. This may offer one explanation for the marked variation in response to Cu therapy which has been widely observed. M any copper deficiency problems in N.Z. are associated with high pasture molybdenum levels (molybdenosis). Mention should be made of a post-parturient haemoglobinuria which has been recorded in association with molybdenum-induced low copper status in Northland (Smith and Coup, 1973). The symptoms include post-parturient anaemia, haemoglobinuria, and absence of or weak signs of oestrus.

Selenium (Se)

Selenium and vitamin E (tocopherol) are associated because the vitamin and a Se containing enzyme, glutathione peroxidase, appear to be involved together in the maintenance of cell membranes; operating as antioxidants. Their involvement in a condition involving rapid degeneration and retention of placentae with subsequent re-breeding problems, has been demonstrated in cows calving during winter in U.K. by Trinder *et al.* (1969; 1973). Supplements of Se, while effective appeared to be not quite as effective as Se plus vitamin E. The problem, interestingly, did not occur during summer. The cows were housed in winter and the difference in incidence was attributed to the normally high pasture content of vitamin E, perhaps having some sparing effect on requirement for Se during summer. In N.Z., where exclusive use of pasture is made, it would appear that simple Se deficiency might exist in cattle as Se related reproductive problems have been well documented in sheep (Hartley, 1963).

The data of Trinder *et al.* (1973) suggest that situations where blood Se levels below 0.08 mg/l and herbage Se levels of less than 0.06 mg/kg DM occur would be worthy of close examination for response to Se supplementation, particularly where cows in a herd are observed to retain placentae. In sheep, however, growth responses to Se supplements are not usually observed on pastures containing more than 0.03 mg Se/kg DM. Moreover, retained placentae do not appear to be a problem in dairy cattle in N.Z. even in animals with very low Se status (R.G. Clark, pers. comm.). In the same animals significant responses in milk production were not found in cows with blood Se levels below 0.007 mg/l (Ryan *et al.*, 1984).

Cobalt (Co)

A Co deficiency in ruminants is really a vitamin B12 deficiency: in the presence of Co vitamin B12 is synthesised by rumen micro-organisms. A lack of dietary Co inhibits vitamin B12 synthesis. In deficiency states the ability of the animal to utilize propionate is impaired and intermediary products are excreted in urine. As a consequence apetite declines. Effects of Co deficiency on fertility are therefore likely to operate through excessive general bodyweight loss rather than through a specific effect of deficiency. Deficiency of Co can be expected where herbage Co is below 0.9 mg/kg DM and where liver reserves of vitamin B12 fall below 0.10 g/g fresh weight or 0.05 mg Co/kg DM. A continuous dietary supply of Co is preferable to intermittent enhancement by drenching to ensure continuous absorption of vitamin B12.

Iodine (I)

Iodine is required for synthesis of the thyroid hormones, tetra- and tri-iodo thyronine. These are transported throughout the body where they are active in controlling energy and protein metabolism of cells. Three types of deficiency occur; simple uncomplicated deficiency due to low dietary I intake, thiocyanate-induced deficiency in which impaired uptake of I by the thyroid gland occurs, and thiouracil-induced deficiency in which thyroid hormone metabolism is impaired. Thyiocyanate-induced I deficiency can be a problem in stock consuming brassica crops, but can be overcome by I supplementtion.

While there is one report of reduction of number of services per conception and minor increase in milk fat production on I supplementation of dairy cattle in N.Z. (McGowan, 1983), the subject needs more thorough research before we could classify I deficiency as a likely problem in dairy cattle. It is generally considered that I deficiency is unlikely if herbage levels exceed 0.5 mg/kg DM when goitrogens are not present. In the presence of goitrogens such as the thiocyanates dietary I levels should be increased to 2 mg/kg DM.

Manganese (Mn)

Manganese, which is a co-factor for many enzyme systems, and is concerned with energy and protein metabolism, has been associated with infertility in cattle. Munro (1966) and Rojas *et al.* (1965) demonstrated poor conception rates when the dietary Mn concentration was below 20 mg/kg DM. It has generally been a problem on light sandy soils with a high pH enhanced by liming. Data currently available for N.Z. pastures suggest that Mn deficiency is unlikely (Metson *et al.*, 1979).

Zinc (Zn)

Zinc is essential for several enzymes involved in carbohydrate metbolism and protein synthesis. There are insignificant stores of Zn in the body and the animal relies on a continuous adequate intake. Zn deficiency has a primary effect on feed intake in growing animals, and there is some evidence (Somers and Underwood, 1969) that this is consequent on impaired protein metabolism. In calves open wounds of the skin around the eye, hoof and scrotum and bowing of hind limbs and stiffness of the joints are typical symptoms of severe deficiency. In sheep failure of normal development of male sexual organs (Underwood and Somers, 1969) and reduced reproductive rate (Egan, 1972) are established symptoms of chronic moderate deficiency. There are however, no reports of similar reproductive problems in cattle.

The dietary requirement for Zn probably lies in the range between 20 and 30 mg/kg DM, and most pastures in N.Z. contain in excess of this concentration. Some pastures, however, notably on pakihi soils on the West Coast of the South Island and others grown on soils in Southland have had values below 20 mg Zn/kg DM and their adequacy for dairy cattle should be investigated.

General

Examination of data from M.A.F. Animal Health Laboratory Diagnostic Services during the 5 year period covering 1979 to 1983 shows that of cattle (dairy and beef) blood samples submitted for mineral analysis, 80% of those found to be 'abnormally low' were for Cu and Se. In the north of the North Island 60% and 20% of abnormal values were for Cu and Se respectively, while in the South Island the distribution was 38% Cu and 48% Se. Magnesium was the next most frequently 'deficient' element, representing about 13% of abnormal samples. Individual case histories can not be examined for subsequent response to treatment. Moreover, one must assume that the most appropriate analyses were always requested. Notwithstanding this, the data do perhaps indicate where greatest attention to assessment of status should be directed.

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THE DIAGNOSIS OF MINERAL DEFICIENCIES AND METHODS OF THERAPY

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Introduction

If a deficiency of a mineral such as copper, phosphorus, iodine or selenium is suspected to be causing infertility it is necessary to confirm this before treatment is instituted. Not only does this prevent unnecessary use of minerals and possible poisoning, but also if mineral deficiencies are eliminated other possible causes of the infertility can be investigated.

It also may be necessary to assess the mineral status of a herd to demonstrate that there are no deficiencies present. There is no evidence that minerals given to cattle with a normal mineral status will artificially stimulate their reproductive rate.

If the levels of one or more minerals are below normal they should be supplemented by suitable material in controlled amounts so as to provide adequate mineral intake without risk of toxicity. Methods and amounts vary with the mineral being supplemented, the degree of deficiency and the situation where the deficiency arises.

Diagnostic tests are laboratory analyses of tissue samples and/or production response trials. In the latter a representative sample of animals is supplemented with the mineral being tested. The response to the treatment is carefully measured and compared with the control group. This is the most definitive test (Underwood, 1981).

Determination of the mineral status of a herd with an infertility problem is only part of the total investigation. It needs to be done in association with investigations into other causes of infertility such as nutritional status, mating management and infectious disease.

Diagnosis of Mineral Deficiencies

Clark (1983) breaks the diagnosis of mineral deficiences into three stages.

(a) Defining or describing the problem.

This involves a careful, accurate and complete definition of the degree and extent of the problem and its background. Information is required on;

— the type and severity of the problem, e.g. anoestrus, irregular returns to service,
— number and type of animals affected (age, sex, breed)
— other disease conditions and-or symptoms present, e.g. diarrhoea,
— expected performance (previous performance, district and national performance),
— soil type,
— pasture type and production,
— climate, and
— management practices, e.g. topdressing programme, pasture irrigation, mating management.

(b) Defining the likely cause(s) of the problem.

Possible causes are listed and examined, taking into consideration the information obtained in (a).

(c) Selection of appropriate tests to diagnose the cause.

In the case of minerals this involves analysis of submitted materials for particular substances. The mineral status of a ruminant is a reflection of the mineral status of the soil and the availability of the mineral to the animal. However the concentration of a mineral in the soil is an uncertain indicator of its concentration in herbage (Underwood, 1981). Soil mineral levels may nevertheless give some indication as to what deficiencies may occur (Towers and Clark, 1983).

Herbage analysis is useful for determining interactions between minerals, e.g. copper-molybdenum-sulphur, and for monitoring the effectiveness of topdressing (Towers and Clark, 1983). It is of limited value in assessing the mineral status of an animal because the effective mineral uptake by grazing cattle varies with;

— pasture intake,
— mineral concentration in the herbage,
— herbage mineral availability, and
— soil contamination of the herbage.

Analysis of tissue gives the best measure of the mineral status of an animal. The tissue selected for analysis will depend on the reasons for the analysis (Clark, 1983). These will include the following.

(a) Problem investigation. To diagnose the cause of poor production select a sample that reflects mineral content where it functions, e.g. plasma for copper.

(b) Disease prevention. To determine if supplementation is necessary to prevent a deficiency occurring select the tissue where the mineral is stored, e.g. liver for copper.

The time of sampling depends on when the problem occurs and the reason for the investigation. If the problem is one of infertility then sampling as close as possible to the time that the problem occurs is necessary. With infertility problems this will probably be in the spring.

If the sampling is carried out to determine whether or not mineral supplementation is necessary to prevent a problem, it should be done before the problem period. As mentioned above the tissue sampled should indicate the reserves of the mineral. Tests to indicate intake also may be relevant.

Concurrent disease may affect some tests, e.g. liver damage may affect serum ferroxidase levels for copper analysis. Also haemolysis of blood may affect some serum levels. These can be prevented by sampling animals showing no disease other than that being investigated and by protecting blood samples from the sun and decanting the serum as soon as possible.

The numbers of samples to take depends on the mineral being analysed because different minerals show different degrees of variation of level between animals. This is caused by biological variation and variation in intake associated with selective grazing and soil ingestion. Ellison (1982) has used these variations to calculate the numbers of samples needed (see *Table 1*). The samples should be selected from the group (e.g. age group) of animals suspected of being deficient. Animals to be sampled should be selected at random from within this group (Clark, 1983).

TABLE 1.

Diagnosis of mineral deficiencies affecting fertility.

Mineral	Does a deficiency affect reproduction?	Samples required for diagnosis	Number of samples	Reference range		units
				adequate	deficient if below	
copper (Cu)*	yes	serum	7	8	4.5	μmol/l
		liver	4-16	>45	45	μmol/kg
iodine (I)	yes	history of thyroid gland		currently no reference range available		
phosphorus (P)	yes	serum (unhaemolysed)	6		1.5	μmol/l
		bone (ash)			45% total bone weight	
selenium (Se)	currently not confirmed in N.Z.	blood	3	250	130	nmol/l
		liver	3	450	250	nmol/kg

*high dietary molybdenum and/or sulphur levels may induce copper deficiency.

Sophisticated and expensive equipment is necessary for analysis of the small amounts of minerals present in body and blood. Analysis of animal tissue is done mainly by the Animal Health Laboratories of the N.Z. Ministry of Agriculture and Fisheries (M.A.F.) at no charge. Some private laboratories also offer these tests.

Details of the type of specimens required for analysis and the number of animals to be sampled for each of the elements; copper, iodine, phosphorus and selenium are given in Table 1.

The reference ranges quoted in Table 1 have been established from published data and from M.A.F. experimental and investigative work. This work is ongoing, thus the values may change. Veterinarians are kept informed of such changes.

Also the reference ranges quoted here are specific for the M.A.F. animal health laboratory service. If other analytical services are used reference ranges relevant to their methods should be used.

Ideally the results of tissue analyses should be reliably related to a measured response following treatment. Unfortunately with bovine fertility the degrees of response to some minerals at certain tissue levels are not well defined. Where this information is not known or results are equivocal, a production response trial is indicated (Towers *et al.*, 1983). In the simplest form this means that;

— a group of animals is divided into treated and control groups on a random basis,

— the critera used to compare the two groups, e.g. calving to first oestrus interval, are set,

— one group is given the mineral being tested, and

— the response of the treated group is compared against that of the control group.

While such trials provide valuable information it is very important to ensure that;

— the objectives of the trial are carefully defined,

— the trial is properly planned,

— the allocation of animals to groups is done randomly,

— treatments are given carefully,

— responses are accurately recorded, and

— the data generated are analysed statistically.

A variation of the simple trial, a multifactorial trial, can be used providing sufficient numbers of stock are available. The planning of these trials is intricate and the analysis of the data is more complex.

As seasonal variations in mineral availability may occur, analytical tests and-or dose-response trials may need to be repeated in different seasons. Changes in farm management such as the introduction of irrigation or the use of molybdenized superphosphate also may change the mineral status of animals, necessitating retesting.

Treatment and Prevention

Treatment of a deficiency necessitates the prompt administration of a rapidly acting form of the mineral to the affected animal. It is preferable that the formulation will provide a source of mineral for several weeks. The metabolism of the element involved will determine the most effective method. While treatment of individual animals is labour intensive it will produce the best results.

Injectable organic complexes of copper and iodine provide a convenient and long acting method of supplementing these elements. This method obviates the need for regular dosing with copper or iodine salts.

Forms of minerals for oral use such as drenching are the cheapest but usually require repeated administration. Many are suitable for mixing with other animal remedies, e.g. anthelmintics, and given as drenches. Other methods such as including the element in salt licks are not sufficiently reliable. Cunningham (1949) showed that grazing sheep dosed with mineral to overcome deficiencies in the pastures ate as much mineralized lick as similar undosed animals. An animals appetite for a mineral is not a reliable measure of its needs.

Indirect methods of mineral supplementation such as adding copper sulphate to fertiliser are applicable to many situations. The method is usually very economical and supplies adequate supplemental element. However some doubts as to its effectiveness for copper have been expressed (Farquharson, 1983) and continual monitoring may be advisable if it is used. Advice should be sought before utilising this method of deficiency correction.

Methods of mineral supplementation used are given in Table 2. The prices of the various treatments have not been included as they may vary considerably.

Recently the use of copper oxide needles which are given by mouth and lodge in the abomasum has been reported as being an effective methods of controlling copper deficiency (Underwood, 1981). However these are not currently available in N.Z.

It is important that the amounts of minerals prescribed for treating and/or preventing deficiences are not exceeded. Each year instances of production loss and death in farm animals in N.Z. occur from over zealous use of minerals.

Conclusion

The diagnosis, treatment and prevention of mineral deficiencies in any situation is a task for professional investigators such as veterinarians. They may work in association with Animal Health Laboratories, scientists and other farm consultants, particularly where fertiliser programmes and economic planning are necessary.

It is important to be aware of the role of minerals in all forms of animal production. It is equally important to be aware that little is to be gained from the haphazard institution of patent mineral remedies at any time, let alone when problems of disease and production become apparent.

The aspects of mineral deficiency diagnosis and therapy discussed here are those known today. It is likely that our knowledge on both the range of minerals involved as well as diagnosis and therapy will change over the years. Veterinarians and farm consultants working in cattle production should be sure that they are conversant with new information as it becomes available.

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IMPROVED REPRODUCTIVE PERFORMANCE

SUMMARY OF THIS SECTION

High submission rate (SR).

To achieve submission of a high proportion of a herd for mating oestrous detection is of paramount importance. In cattle oestrous behaviour persists, on average, for 14 to 15 hours. During this period cows in oestrus (on heat) will stand to be mounted by other cows or the bull and will attempt to mount other cows themselves. In a herd a number of cows may be in oestrus at any one time. Such cows form sexually active groups and large herds obviously favour the formation of such groups. A variety of errors in the detection of oestrus can arise. For instance it may not be detected in some cows, particularly during the latter stage of the breeding programme when most cows are pregnant so less are available to form sexually active groups. Another error is wrong diagnosis, in which case a cow is inseminated whilst not in oestrus. This is not serious but will lower the conception rate. Finally there is the problem of presenting the wrong cow for insemination because of mistaken identity.

Oestrous detection by visual observation of the herd requires at least three 20-minute periods of observation during the day, between milkings. Other detection techniques employ marker bulls with chin ball harnesses, tail painting or heat mount detectors. Tail painting is the most widely used aid in dairy herds but a common fault is to apply the paint too thickly.

The whole programme is assisted by keeping good records throughout pre mating as well as during the insemination period. SR records are retrospective but are essential if a fertility problem arises and the cause needs to be diagnosed. The A.I. programme should cease abruptly when vigilance at oestrous detection wanes, and mating then handed over to entire bulls.

High conception rate (CR).

A.I. should be timed so that cows are inseminated at the first opportunity after they have been shown to be in standing heat. Cows seen in heat at the evening milking should be inseminated the following morning, and cows seen in standing heat at the morning milking should be inseminated that morning. There is no advantage in inseminating on a particular farm more than once a day and there is no advantage in delaying insemination more than 24 hours after cows have first been noticed in heat.

By the end of 4 weeks of an A.I. programme 95% of a herd should have been submitted for insemination. If the CR, based on 0-22 day non return rate, is below 65% professional help should be sought immediately.

Farmers can ensure satisfactory insemination by providing good facilities for a competent A.I. technician and purchasing semen from proven bulls.

Oestrous synchronisation.

Many of the objectives of reproductive management can be enhanced by synchronisation of oestrus. This is achieved by using prostaglandins or progestagens to induce the next oestrous cycle. Although these two groups of drugs work quite differently, the final result is the same. In either case the essential requirement is that each cow must be experiencing oestrous cycles at the time of treatment.

Most of the systems in use involve giving 2 prostaglandin injections 11 or 12 days apart. Use of progestagen-releasing devices will be limited until regulations which prevent the inclusion of oestrogens are rescinded.

Induction of parturition.

Induction of premature parturition is another management tool for use in planned reproductive programmes, provided it is not used as a salvage operation to tidy up late-calving cows.

Treatment must be timed so that the last cows calve at least 5 weeks before the start of the next mating season. The induction programme has to be planned early and decisively. Most procedures use a 'priming' treatment of a slow-acting corticosteroid followed, 10 or 11 days later, by a 'trigger' dose of a prostaglandin or a short-acting corticosteroid.

Issues of concern such as, retained foetal membranes, subsequent reproductive performance and calf survival, appear to have been overcome in most situations.

PRACTICAL RECOMMENDATIONS FOR ACHIEVING HIGH SUBMISSION RATES IN DAIRY HERDS

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Introduction

The average number of cows per herd in N.Z. in 1981/82 was 133. In the early 1960s it was 65, and in 1971/72 it was 102. This herd-size trend has occurred even though the average number of labour units per herd has varied only between 1.4 and 1.2. Therefore the number of cows per labour unit has shown a similar proportional increase to that of cows per herd. It has increased from 50 cows per labour unit in the early 1960s to 102 cows per labour unit in 1981/82. These statistics are important when considering management procedures for recommendation to a herd owner who is endeavouring to obtain a high submission rate during his herd's artificial breeding (AB) programme.

Each cow in the herd must be regarded as an individual, in that each animal must be inseminated during or shortly after the end of oestrus. If behavioural symptoms are to be used to detect oestrus, then each animal must be observed and invidually diagnosed. This objective must be achieved within the framework of having a large number of animals in one herd being observed by a limited number (usually one) of people.

Oestrus and Oestrous Behaviour

It is preferable to identify aspects of oestrus and associated behaviour which should or could be used to diagnose oestrus, before comparing the efficiency, cost and convenience of different methods of detection.

Oestrus is broadly defined as that period of the oestrous cycle during which a female (cow, ewe, sow, etc.) is receptive to the male, is usually 'sexually attractive', and may seek out a male. Species specific and even breed specific behavioural symptoms are associated with oestrus. Oestrogens, e.g. oestradiol, reach their highest levels of the cycle during oestrus. Many of the behavioural symptoms of oestrus can be induced by injections of these hormones. In the normal cycle the oestrous condition is 'programmed' to coincide with or slightly precede ovulation so that a female is served a few hours before ovulation occurs. This is because an ovulated ovum rapidly loses its potential ability to be fertilized and to develop normally.

The peculiar characteristic of oestrus in cattle is that an oestrous cow will stand to be ridden by other cows as well as by a bull. This does not occur in other domestic mammals. It is a major behavioural characteristic which facilitates detection of oestrus, especially if cows in a herd are grazed at high stocking rates and there are several cows in oestrus simultaneously. Under these conditions, the cows in oestrus form 'sexually active groups'. Intensive riding activity occurs within these groups which may be joined temporarily by non-oestrous herd-mates. Cows in oestrus will mount as well as standing when mounted, whereas non-oestrous cows rarely stand when mounted. Interactions between cows in oestrus are not greatly influenced by the social order in the herd — dominant cows will ride and be ridden by subordinate cows. Animals actively involved in a sexually active group spend less time grazing and ruminating and often fail to have a normal milk let-down. Their body temperature may be elevated slightly and they display varying intensities of restlessness, often associated with bellowing.

In N.Z. dairy cows, the average duration of behavioural oestrus is 14 to 15 hours with about 20% of cows being detected in oestrus at two consecutive milkings. This proportion is not affected by age. The duration of oestrus may vary from 'zero' (silent heat) to about 30 hours. It is influenced by time of day and number of herd mates simultaneously in oestrus.

For example, sexually active groups tend to form at the end of a post-milking intensive grazing period. Activity wanes in the early afternoon, but intensifies once more as the herd becomes restless before the p.m. milking. There will be further activity in the evening, but much less during the main hours of darkness. Therefore a cow may 'be in oestrus' for several hours **before** a period of increased activity. While some cows may 'seek out' a bull most cows prefer to mount each other. It is this riding activity which signals the bull that a sexually receptive oestrous cow may be in that vicinity. Within a period of oestrus cows will ride each other before they will stand for a bull. Service by a bull will often shorten the duration of behavioural oestrus.

For these reasons, statistics on the duration and intensity of oestrus tend to be very variable. In addition, oestrous behaviour can be influenced by many environmental factors. Adverse weather conditions (high temperatures or cold rain with wind) can reduce the frequency and intensity of behavioural interactions. In spite of these limitations N.Z. herd owners should recognise the considerable advantage they have, with large herds grazing pasture at high stocking rates in a moderate climate. These conditions are ideal for the formation of sexually active groups. Problems of oestrous detection arise either when group formation is restricted and does not occur or when animals within a group cannot be identified positively.

Errors in the Detection of Oestrus

Systems of oestrous detection will produce errors of differing types and frequency. There are three main types of errors. Each can be of differing importance in its effect on submission rate.

The three types of errors are;

(a) errors-of-omission,
(b) errors-of-diagnosis, and
(c) errors-of-identification.

(a) **Errors-of-omission** occur when an oestrous cow is not detected because of inadequate behavioural symptoms or unobserved symptoms. This type of error must contribute to a reduced submission rate and delay the period until insemination and possible conception by at least one cycle (approx. 3 weeks). The effect is the same as submitting an undetected cow for insemination but then not bothering to inseminate it. Poor oestrous detection and too conservative diagnosis produce this type of error. It is extremely common in small herds kept indoors and milked year round, as in Europe or America. It is common also in N.Z. herds from 6 weeks after the start of a successful AB programme, when most cows in the herd will be pregnant and sexually active groups thus less likely to form. A single bull run in a large herd may also make this type of error.

(b) **Errors-of-diagnosis** occur when some weaker behavioural symptoms usually associated with oestrus are liberally interpreted and result in mis-diagnosis. When this occurs a cow will be inseminated when it is not in oestrus and therefore cannot conceive. This type of error will not reduce the submission rate, but must reduce the conception rate to first insemination. It is the most common type of error in N.Z. herds. Provided it does not produce an oestrus/insemination — non-oestrus/insemination sequence, this error need not delay date of conception. Accepting a reasonable frequency (a maximum of 10%) of this type of error should mean that cows with less obvious symptoms of oestrus may still be inseminated at the appropriate time, rather than become an error-of-omission.

(c) **Errors-of-identification** occur when an animal is correctly diagnosed in oestrus, but a herd-mate is submitted and inseminated because of mistaken identity. This type of error may reduce submission rate and will definitely reduce conception rate. It is most common in large herds, either where owners do not use clearly readable eartags and brands, or where visual observation is the only method of oestrous detection used in that herd. It is likely to occur when animals are being identified from a distance by less-experienced staff.

Methods of Oestrous Detection

The most efficient methods for detection of oestrus in dairy cows utilise the more reliable behavioural characteristics. Body temperature, vaginal mucus consistency, mucous conductivity, and odometer measurements have not proved reliable or practical in N.Z. herds. The most common methods used independently, or in selected combinations are; (a) frequent visual observation for mounting activity, (b) vasectomised bulls fitted with a chin ball harness, and (c) tail painting or 'heat mount' detectors. All techniques have worked successfully in some herds and less successfully in others.

The following comments can be made about each technique.

(a) **Visual observation** works satisfactorily when the person who does all the observations can readily recognize each cow from a distance. The observer should check the herd at least three times every day between milkings. Thoroughness is imperative and each observation period should last for 20 minutes, preferably during those times when grazing is less intense but before the herd has settled. This form of detection is difficult if cows are not heavily stocked so that the frequency of encounters between animals is not sufficient to allow sexually active groups to form. For the same reason, visual observation alone cannot be recommended for use after the first 6 weeks of AB.

(b) **'Marker' bulls** work best when at least two bulls are in the herd at any one time. An element of competition is important if 'seeking' activity is to be maintained adequately. The most recently marked cows should be removed from the herd and bulls should be changed every 3 or 4 days during periods when a large number of cows are in oestrus. Otherwise many bulls will concentrate on a small number of selected cows and also lose interest.

In a small herd which is not heavily stocked or is not intensively handled (e.g. a beef herd), marker bulls may be the most effective form of detection. These bulls should not be allowed to enter a crowded cattle yard or milking yard. Some bulls may serve non-oestrous cows which cannot escape (rape!) and others may mark non-oestrous cows when moving their heads above other animals.

The marker bull technique requires sexually active (young) bulls and each must be fitted with a chin ball harness. The harness must be operational and not cause discomfort to the bull; a problem usually arising from straps over the nose or behind the ears. It is preferable to use harness fluid which is colour-contrasted with the cattle coats. For example, yellow fluid is not satisfactory with Jerseys but quite satisfactory with Angus. The reverse applies with magenta fluid. Harnesses must be checked and refilled twice each week.

(c) **Tail painting** or heat mount detectors are forms of detection which rely on the riding activity among cows in a sexually active group. Heat mount detectors can be used successfully where this activity is less intense or infrequent and cows are not grouped tightly into yards. In contrast, tail paint is designed for use in herds of over 90 cows with a single seasonally concentrated AB programme. It will work most effectively during the first 6 weeks of this programme when sexually active groups are readily being formed. A single mount should not disturb the paint strip. Hair shedding can provide interpretation problems for less-experienced operators.

Tail paint has proved to be effective in groups of synchronised cattle. It also has been used successfully in conjunction with visual observation to allow owner to check a cow at closer quarters, or to minimise the occurrence of errors-of-identification. It can be used by staff who may not readily be able to recognise every cow in the herd.

An essential requirement with tail paint and heat mount detectors is that the paint strip or detector must cover 'rubbing points'. These points should be identified before a detector or paint is applied. Suitable paint must be used for tail painting and suitable glue with a detector. Most herd owners apply tail paint too thickly and over a length which extends beyond possible rubbing points. This can complicate interpretation.

Tail paint is the most widely used aid to detection in dairy herds. It is preferable to use it in conjunction with observation for oestrus. Under these circumstances an experienced user of tail paint can detect accurately over 90% of all cows which display oestrus during the first 3 weeks of the herd's AB programme. It can also be used during the pre mating period, but it is less satisfactory in the post AB or post mating periods. Using paints of different colours can allow groups of animals to be identified conveniently (e.g. unmated animals). The paint strip should be checked at least once each day and renewed if it is scuffed or there is hair shedding. Detected cows should be drafted out only once each day so that sexually active groups are maintained for as long as possible. Inseminated cows should not be repainted, at least until the following milking.

Achieving High Submission Rates

If the objective of a high submission rate is to be achieved, then a herd owner must successfully integrate pre mating planning with the vital management decisions made during his breeding programme, especially during the first 3 or 6 weeks of that programme. In the pre mating period the methods selected for detecting oestrus during the breeding programme must be tested. Tail paint techniques must be tested (e.g. application and interpretation). Marker bulls should be vasectomised and libido tested, as well as trained not to enter the milking yard.

If an induced parturition programme is used in a herd then its implementation should have recognised the need to allow cows at least 6 weeks from calving to an insemination during the first 3 weeks of an AB programme. The simple ideal is to have the first injection of an induced parturition programme administered **2 calendar months** before the start of the AB programme, e.g. 1 September as an 'induction treatment' date would coincide with 1 November as a 'start of AB' date. Practical realities must temper the implementation of this recommendation.

'Pre mating heat' dates can be useful for resolving problems of diagnosis and for detecting cows with abnormal cycles, especially short cycles associated with cystic follicle conditions. Potentially non-cycling cows can be identifiedimmediately before the AB programme commences. Since it is common for the first post-partum ovulation to occur without behavioural oestrus, an owner should accept that some of the 'unobserved' cows may have ovulated without displaying oestrus. Nonetheless, these animals should be injected with a prostaglandin by the veterinarian so that most are inseminated during the first 3 to 4 days of the AB programme.

While these pre mating aspects of breeding management are important, by far the most important is **vigilance** during the **entire** AB programme. This is the time when the errors which can be made are of greatest consequence. Pre mating heat records should not be relied on because a diagnosis should be made on current symptoms and not on historical records. Too great a reliance on the latter will result usually in too many cows being inseminated too early. If a diagnosis for a particular cow is doubtful, submit the cow for its **first** insemination but **record** the doubt (as a ? by the cow's number). The doubt will usually be resolved without allowing a cow with less obvious symptoms of oestrus to become an 'error-of-omission'.

Complete pre mating heat records can allow progress results during the first 3 weeks of an AB programme to be related to expected results. If the latter exceeds the former, then veterinary advice should be obtained. Even if pre mating records have not been kept, **all** unmated cows should be examined per rectum around 24 days after the start of an AB programme. Cows which have been detected in oestrus but which have ovulated can be identified and treated with rostaglandin to minimise the delay in the interval to first insemination.

End of AB Programme

The insemination programme should be terminated abruptly once a herd owner can no longer convince himself that 'vigilance' in detecting cows in oestrus is operating within his herd. Vigilance may decline because of other management objectives (e.g. silage making), few cows in oestrus or loss of interest. Most herd owners delay in making a positive decision and consequently make errors-of-omission.

When the decision is finally made at least two entire bulls (preferably each fitted with a harness) should be allowed to run with the herd. These bulls should have a high ancestral breeding index (BI). If the need arises their female progeny can be retained as herd replacements when insufficient AB progeny are available.

Analysing Breeding Records

Records can be used to identify those factors which probably contributed to an unsatisfactory result in a herd's breeding programme. Records are **retrospective**. In most cases it will not be necessary to use them. Howounsatisfactory result does occur, but no records or incomplete records have been kept, then the herd owner must recognize that he has contributed substantially to any difficulties encountered in diagnosing or identifying the causative factors.

If the AB programme has not produced satisfactory results, but complete records are available, then the records should be appropriately analysed in the following sequence.

(a) What was the herd's 3-week submission rate?

(b) What was the herd's 3-week conception rate to first insemination?

(c) What proportion of the return intervals to first inseminations were short (1 — 17 days), normal (18 — 24 days) or long (25 — 49 days)?

The results of these calculations will indicate which area of investigation should be pursued further, but additional advice may be required. Greater emphasis must be placed on the final outcome, the **calving pattern**, because that is the pattern which can maximise or reduce subsequent average lactation lengths and average per cow production.

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PRACTICAL RECOMMENDATIONS FOR ACHIEVING HIGH REPRODUCTIVE PERFORMANCE TO ARTIFICIAL BREEDING

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Introduction

The main value of artificial breeding (AB) is to maximise genetic gain of a dairy farmer's herd at the least cost. To obtain this objective a farmer needs to use the highest breeding index (BI) bulls with high reliability at reasonable cost. He must also have a programme which ensures a 365 day calving interval and a narrow calving spread without relying heavily on induced parturition. To obtain high reproductive performance when using AB farmers must consider the factors discussed earlier (Rhodes, this publication). That is; herd fertility, mating management, semen quality and artificial insemination (A.I.).

Cow Fertility

Nutrition.

It is obviously important that cows are healthy and cycling at mating time. Cows should be in reasonable body condition at calving and be well fed from calving to mating to ensure nutritional anoestrus is avoided.

Calving spread.

When widespread calving is anticipated the judicial use of calf induction should be implemented two calendar months prior to the start of the AB to 'tighten up' the breeding programme.

Empty cows.

Do not carry over empty cows from one season to the next.

Mating Management

Identification.

The first part of a recording system, which is essential for a **continued** successful AB programme, is to have cows clearly identified. There is developing a national identification system which uses either brass tags or tattoos as a permanent identifier. Each animal has a unique code made up of a herd code, the year the animal was born, e.g. 83, followed by the serial number, e.g. 831, 832, 833, etc. This unique identifier is too large to be used routinely and it is recommended that each cow is given a temporary herd number for day to day identification. As individual cows are lost from the herd temporary identifiers can be given to new calves. The computer will convert the temporary codes back to the unique identifiers. This system also ensures that each animal is identified twice which will minimise loss of identification through loss of an individual ear tag.

Records.

Keeping, and more importantly using records is essential to maintain high reproductive performance. The main value of records in relation to AB is that they allow the farmer or his A.I. technician to identify problems earlier than would be the case without records. This will often mean that a problem can be detected in time for corrective action during the current breeding season rather than at the end of the season or at next calving.

There are many different recording systems in use. The most commonly used is the Livestock Improvement Association's notebook and mating management charts. Day to day information is recorded in the field in the 'calving and mating handbook' and the mating information is transferred to the 'mating management chart'.

Timing of A.I.

In principle cows should be mated in the latter two thirds of standing heat or within a few hours after having gone off standing heat, that is, within 24 hours of the cow first being noticed in standing heat (*Fig. 1*).

Cows should be inseminated at the first opportunity after they have been shown to be in standing heat. Cows seen in heat at the evening milking should be inseminated the following morning, and cows seen in standing heat at the morning milking should be inseminated that morning.

Cows that are thought to be only just coming into standing heat at the time of insemination may be best carried over to the following day for insemination. Alternatively if these cows are inseminated that morning and are still in standing heat the following morning they may be reinseminated. This should not be done unless either there is semen available from the same bull or there is no requirement on the parentage of the particular calf. **There is no advantage in inseminating on a particular farm more than once a day and there is no advantage, in fact several disadvantges, in delaying insemination more than 24 hours after cows have first been noticed in heat.**

Pre mating heats.

If farmers are not fully confident of obtaining reproductive objectives when using AB, it is recommended that several weeks before AB commences pre mating heats should be observed and recorded. This can be done by simply putting a diagonal line through the cow's number on the mating management chart. If she is seen in heat again a second diagonal line is placed through the cow number at right angles to the first.

Subsequent heats if they occur can be recorded with a horizontal and then a vertical line. Observing and recording pre mating heats gives the farmer confidence in his ability to detect oestrus well before the breeding season commences and allows him to have examined cows that have calved six weeks and have not been observed in season.

Cows that have active ovaries may be injected with prostaglandins and inseminated on the first few days of AB. Cows that have been in heat for four or more times during the pre mating period also should be examined.

Mating heats.

Cows observed in heat should be recorded in the appropriate section in the calving and mating handbook. This field recorded data is transferred to the mating management chart (*Fig. 2*) and recorded against the individual cow number ('mating record and check chart') and in date

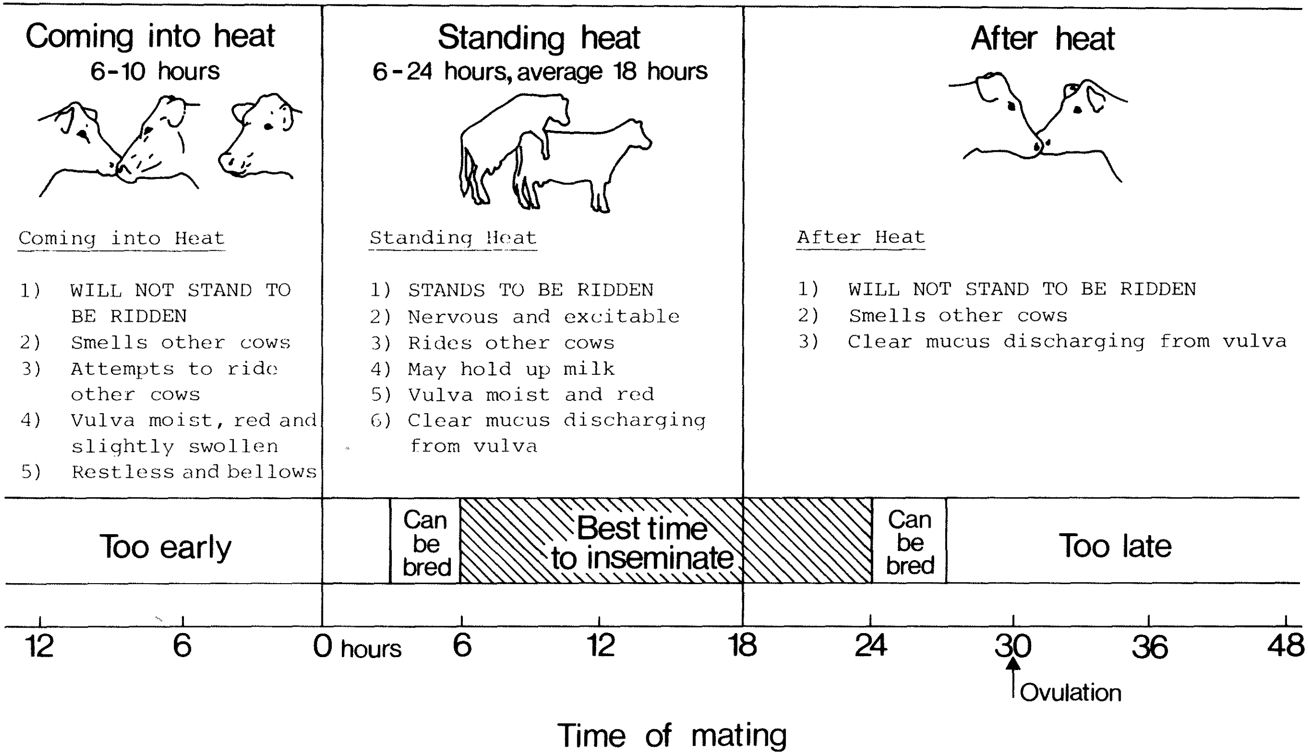
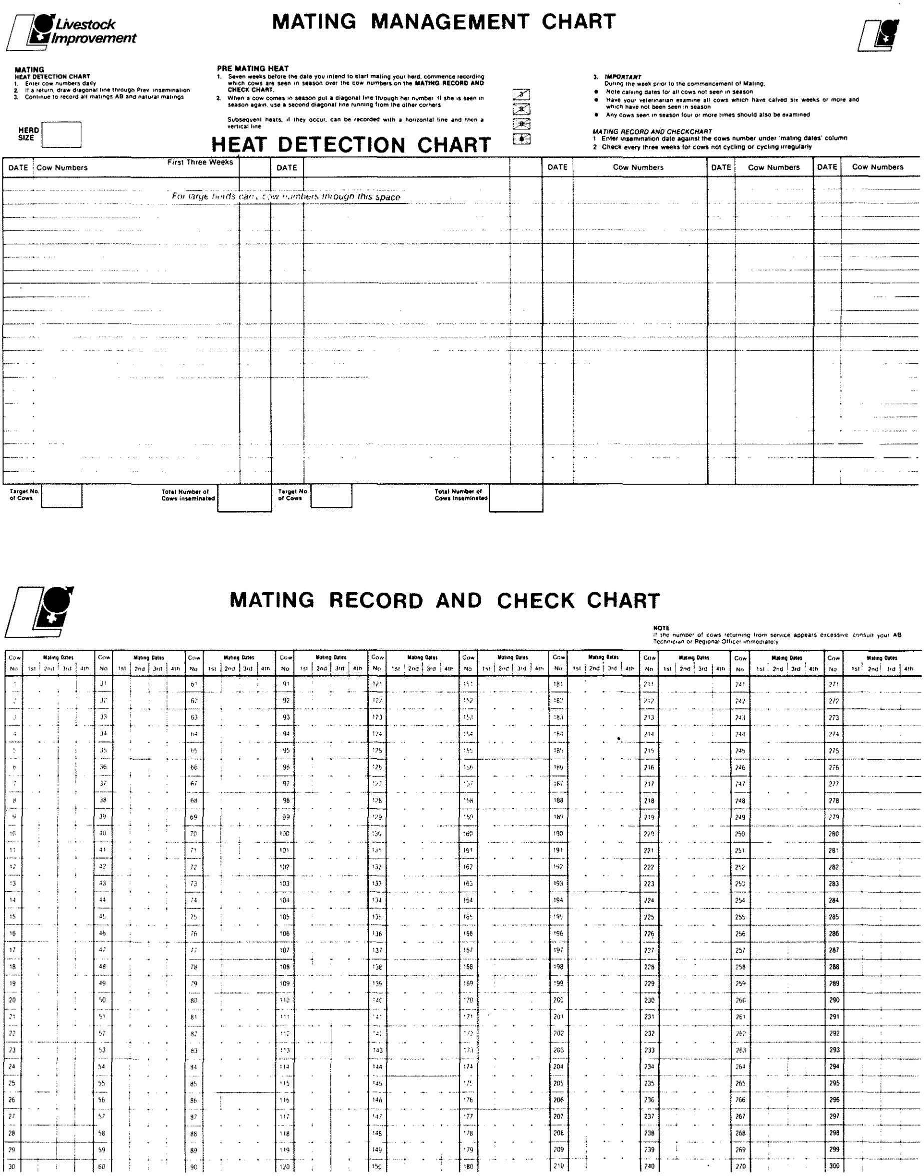


Figure 1: Diagram showing stages of oestrus (heat) in relation to time to inseminate.



Livestock Improvement

MATING MANAGEMENT CHART

MATING
HEAT DETECTION CHART
1. Enter cow numbers daily
2. If a return, draw diagonal line through Prev. insemination
3. Continue to record all matings AB and natural matings

PRE MATING HEAT
1. Seven weeks before the date you intend to start mating your herd, commence recording which cows are seen in season over the cow numbers on the **MATING RECORD AND CHECK CHART.**
2. When a cow comes in season put a diagonal line through her number. If she is seen in season again, use a second diagonal line running from the other corners.

Subsequent heats, if they occur, can be recorded with a horizontal line and then a vertical line

3. *IMPORTANT*
During the week prior to the commencement of Mating:
- Note calving dates for all cows not seen in season
- Have your veterinarian examine all cows which have calved six weeks or more and which have not been seen in season
- Any cows seen in season four or more times should also be examined

MATING RECORD AND CHECKCHART
1. Enter insemination date against the cows number under 'mating dates' column
2. Check every three weeks for cows not cycling or cycling irregularly

HERD SIZE

HEAT DETECTION CHART

DATE	Cow Numbers (First Three Weeks)		DATE			DATE	Cow Numbers	DATE	Cow Numbers	DATE	Cow Numbers
	For large herds carry cow numbers through this space										

Target No. of Cows | Total Number of Cows inseminated | Target No of Cows | Total Number of Cows inseminated

MATING RECORD AND CHECK CHART

NOTE
If the number of cows returning from service appears excessive consult your AB Technician or Regional Officer immediately

Cow No	Mating Dates 1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th	Cow No	1st	2nd	3rd	4th
1					31					61					91					121					151					181					211					241					271				
2					32					62					92					122					152					182					212					242					272				
3					33					63					93					123					153					183					213					243					273				
4					34					64					94					124					154					184					214					244					274				
5					35					65					95					125					155					185					215					245					275				
6					36					66					96					126					156					186					216					246					276				
7					37					67					97					127					157					187					217					247					277				
8					38					68					98					128					158					188					218					248					278				
9					39					69					99					129					159					189					219					249					279				
10					40					70					100					130					160					190					220					250					280				
11					41					71					101					131					161					191					221					251					281				
12					42					72					102					132					162					192					222					252					282				
13					43					73					103					133					163					193					223					253					283				
14					44					74					104					134					164					194					224					254					284				
15					45					75					105					135					165					195					225					255					285				
16					46					76					106					136					166					196					226					256					286				
17					47					77					107					137					167					197					227					257					287				
18					48					78					108					138					168					198					228					258					288				
19					49					79					109					139					169					199					229					259					289				
20					50					80					110					140					170					200					230					260					290				
21					51					81					111					141					171					201					231					261					291				
22					52					82					112					142					172					202					232					262					292				
23					53					83					113					143					173					203					233					263					293				
24					54					84					114					144					174					204					234					264					294				
25					55					85					115					145					175					205					235					265					295				
26					56					86					116					146					176					206					236					266					296				
27					57					87					117					147					177					207					237					267					297				
28					58					88					118					148					178					208					238					268					298				
29					59					89					119					149					179					209					239					269					299				
30					60					90					120					150					180					210					240					270					300				

Figure 2: Livestock Improvement Association mating management chart.

order ('heat detection chart'). If when recording the heat on the 'mating record and check chart' it is observed that the cow already has been recorded as being on heat since the start of AB, put a line through the previous insemination on the 'heat detection chart'. This will allow easy calculation of submission and later conception rates. If the number of cows returning to service in this early period appears high the problem should be discussed with the A.I. technician, his Supervisor or veterinarian.

The mating management chart allows easy reference to cows that have not cycled and the dates of those that have. The 'heat detection chart' will give ready reference to submission rate (SR). There should on average be four cows cycling per day for every 100 cows in a seasonal calving herd. That is, 85 percent of the cows should be submitted in the first three weeks of AB and by four weeks 95 percent of the herd should be submitted.

If these guideline figures are not being obtained professional advice should be sought immediately. After three weeks of AB conception rate (0 — 22 day non return rate, CR) figures can start to be calculated. Obviously the earlier these calculations are done the earlier a fertility problem will be detected. Conversely, when only a few cows are included in the calculation the CR figures will not be very reliable. By the end of the four weeks on AB a reasonable number of cows will have gone three weeks since being inseminated and a reasonable indication of the herd's CR be obtained. The CR should be in the vicinity of 75 percent on a 0 — 22 day non return rate basis. If the CR on a reasonable number of cows is below 65 percent professional advice should be obtained immediately.

After four weeks AB all cows not observed in oestrus should be subjected to veterinary examination. Where cows have active ovaries consideration should be given to treatment with prostaglandins and these cows watched carefully over the next week.

At the end of AB bulls should be run with the herd to 'finish off' the breeding programme.

In the Livestock Improvement Association system inseminations are recorded in the farmer's AB docket book. From these data a schedule of inseminations is returned to the farmer at the end of the season.

Farmers are recommended to add to these records cows that have been naturally mated and cows not in calf so that an accurate computer listing of cows expected to calve and calving dates can be provided. This information is the start point in planning a successful breeding season the following year.

A.I. Technicians

With A.I. technicians now being trained by at least four different organisations in N.Z. it is imperative that farmers are confident of the training standards, the level of supervision of the inseminating technician and if the organisation has a field monitoring system for checking technician's conception rate.

Farmers inseminating their own cows (D.I.Y.) should insist on a high standard of training and be prepared to accept that not all people that undergo training will make satisfactory inseminators. CR data should be followed carefully until the D.I.Y. operator is confident of his or her ability to inseminate cows successfully.

For the A.I. technicians to perform their best it is essential that dairy shed design incorporates a system to restrain cows in a comfortable position with the technician being able to stand comfortably at the same level behind the cows. A booklet is being prepared to give specific advice in this area. These will be available through the Livestock Improvement Association South Island office.

Yearlings

Artificial breeding of yearlings is recommended only if all of the following conditions can be met.

(a) Well grown healthy yearlings.
(b) Good facilities for restraining animals.
(c) Farmer assistance at the time of insemination.
(d) Quiet yearlings that are used to being handled.
(e) An efficient method of oestrous detection, ideally involving the use of tail paint.

Semen Quality

The best bull in the world is useless unless he gets the majority of cows mated to him in calf. Now that there are four processing centres in N.Z. and semen is being imported from Australia, Canada and the U.K. it is recommended that the quality control programmes and in particular the monitoring of CR data in the field be investigated prior to using semen from any particular organisation. Where an individual bull is going to be used widely within one herd it is essential that accurate CR data is available on that bull to back up satisfactory semen quality laboratory tests. If satisfactory CR data on an individual bull are not available it is strongly recommended that several bulls be used to cover a potential problem animal.

Before a N.Z. Dairy Board bull is put into the proven team he is checked for both semen quality and CR. The Premier Sires Service approach of the Dairy Board gives the herd owner further confidence about the team approach for maintaining uniformly high CR standards.

Summary

As fertility is an all or none phenomenon, that is, a cow either conceives or she does not to an individual insemination, a breakdown in any one of the above factors can result in poor reproductive performance within an individual herd. It is, therefore, essential when undertaking an AB programme that each of the above factors is carefully considered.

PRACTICE AND PLACE OF OESTROUS SYNCHRONISATION AND INDUCTION OF PARTURITION IN DAIRY HERDS

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OESTROUS SYNCHRONISATION

Introduction

Attempts to synchronise oestrous cycles of the majority of a group of females are being rewarded with increasing success. Perhaps the earliest reason for exploring this concept was to provide for herd owners a means to achieve the required number of inseminations within a short period of time. The application of artificial breeding (AB) with whole groups of heifers, insemination of batches of town supply dairy cows, and the concentration of natural mating programmes are further examples of objectives which are made easier to achieve by synchronisation. However the potential for concentrated conception patterns is no longer exploited just for greater ease of convenience during the mating season.

Once synchronised pregnancies have been achieved and identified, the winter management of the pregnant herd and the management of calving and group calf-rearing, all become areas with potential for increased efficiency. Similarly the changes in calving pattern and median calving date which result from the high conception rate at the start of mating will allow the suitability of traditional dates for the start of calving to be reassessed. None of these possibilities should be dismissed by either beef breeders or milk producers as being of little consequence to their particular operation.

Techniques

Drugs presently available attempt to produce synchrony in one of two ways — the prostaglandins (PGs) hasten the onset of the next cycle, while the progestagens (usually) delay it. With both the initial result is the same. The hormone (progesterone) which prevents the next heat declines in all correctly treated animals at about the same time, although the interval from this decline to oestrus and ovulation can vary quite markedly from cow to cow. Consequently highest pregnancy rates are obtained when insemination or hand mating is based on detected oestrous behaviour. Mass insemination, either once at a certain time, or twice at two set times, used to be widely recommended and still is in situations where the efficiency of heat detection is poor, but on average 20% of such a group will be inseminated with little or no chance of conceiving. Some of this loss or wastage will be offset when PGs are used, through the 10% improvement in the conception rate of treated animals which are inseminated at the correct time. This fertility effect will clearly be more obvious when all inseminations are made following heat detection. Thus, with present methods of treatment, the term 'oestrous synchronisation' is somewhat misleading.

Note the use of the phrases 'next cycle', 'next heat' and 'correctly treated animals' in the preceding paragraph. Animals which have not had one cycle obviously cannot have the intervals between their cycles shortened or lengthened. When there is uncertainty about the cyclicity of some of a group, unsuitable animals are bound to be treated. Such animals may be anoestrous for any of a number of reasons, including pregnancy, and PG treatment may well result in more harm than good.

Progestagens occasionally appear to have shortened the interval from calving to first post-partum heat. However their use for this purpose in herds with a high incidence of anoestrus is unlikely to be effective.

Ovarian activity is thus a pre-requisite for the selection of animals for treatment. The use of tail paint or harnessed bulls for three weeks before treatment is often recommended. Veterinary examination of those cows not detected by these methods can be made on the day of treatment. The first ovulation after calving may not be associated with oestrous behaviour, but such silent heats still leave the animal in a state suitable for treatment.

A variety of synchronisation programmes have been devised, and the individual herd owner needs to be very clear in his own mind about his objectives and the amount of time and expense he is prepared to commit to achieving them. Only then can he and his advisers decide on the programme most suitable for his purposes. Few systems can be regarded as cheap, nor will the most expensive ones always be successful, especially when animal identification and handling facilities are of a poor standard.

Some treatment systems are better suited to heifers, others to lactating cows. In the following examples it is assumed that only suitable animals will be treated, i.e. that their cyclicity has been confirmed either by heat detection beforehand or by veterinary examination on the day of treatment.

Prostaglandins: heifers and dry cows.

(a) System PGa.

Inject all animals twice with PG, with an interval of 11 or 12 days between injections. The majority will be in oestrus during the period 60 h to 120 h after the second injection. Five yardings should therefore be all that are required — two for injecting and three for AB. The number not cycling by the end of the third session of AB is usually too few to warrant a fourth session, unless this can be achieved very easily. With care, weekend work can be avoided, which makes the system very suitable for run-off or agistment situations.

(b) System PGb.

Inject the whole group, and inseminate those detected in oestrus during the third, fourth and fifth day after treatment. Draft these off and inject the rest with a second PG dose, 11 or 12 days after the first injection. A second AB session commences three days later. This system reduces drug costs, but increases labour requirements and produces a slightly longer calving spread. One day of the programme will fall at a weekend — the day of first injection for example.

(c) System PGc.

As against the above two examples, which require no knowledge of heats prior to treatment (other than that they have occurred and did so during the three weeks before treatment), this system uses slightly more detailed information. It avoids wastefully treating those animals which are about to come into oestrus naturally (and therefore do not need treatment), and also those which were on heat during the few days immediately beforehand (and therefore will not respond since neither PGs nor progestagens can cause an animal to have two heats within a week). Animals in both of these categories can respond only to the second injection, and if their inclusion in the first treatment can be avoided, up to half the drug costs can be saved. Heat dates are recorded during the 21 days (Day 1 to Day 21) before the first treatment date (Day 22). Only those animals bulling on or between Days 7 to 17 are treated on Day 22, while all animals are injected on Day 33 (or 34). Insemination upon detection of heat can then be confined to a three-day session as in System PGa. Alternatively, those in oestrus after the Day 22 treatment can be inseminated (this will include some of the untreated cattle) and the balance injected on Day 33 (or 34). This produces two AB sessions 11 or 12 days apart as in System PGb.

(d) System PGd.

Of the many variations suitable for use in dry stock, this system may appeal to those wishing to inseminate some (50% or less) rather than all available animals. It can be adopted also by those who make a late decision to concentrate their AB programme. For example, if only 40% of a group is to be inseminated, then heats are detected and recorded for as many days as it takes 40% to show oestrus, providing that this period does not exceed 12 days. The balance are removed and joined with the bull. The 40% are left for one week, injected once and inseminated upon heat detection. It is obviously not suitable for use in groups where anoestrus is common. If the number selected is short of the target by 12 days, the system must either be abandoned or else proceeded with as described but with fewer animals than planned.

Prostaglandins: lactating dairy cows.

The twice-daily yarding of dairy herds allows any of the above systems to be used, as well as other attractive modifications.

(a) System PGe — seasonal herds.

The common practice of recording pre-mating heats, and the familiarity of herd owners and their staff with the requirements of an AB programme can be combined to achieve the objectives of AB in two weeks rather than in seven weeks. PG usage should not approach one dose per 40% of the cycling cows.

The first week of AB proceeds normally. On the eighth day (which for convenience should be a Monday) the cows which were in oestrus during the eight days before AB started are injected. Those with no recorded pre-mating heats are examined on this same day, and suitable animals also treated. In this way the cows which were due to cycle during the third week of AB are brought into the second week, as are most of those with silent or unrecorded heats. Provided that there is not a high level of anoestrus in the herd, this system will ensure that sufficient cows are inseminated for the production of the usual number of replacement heifer calves. A decision to use this system can be made somewhat belatedly.

(b) System PGf — town supply herds.

Where it is planned to mate groups of cows or heifers throughout the year system PGe can be used repeatedly with, say two weeks, of mating in every eight or ten weeks. An alternative would be to mate batches of animals during the first three or four days of each month, or alternate months. The selection of suitable animals will be the key to success, and will ensure that established pregnancies are not accidentally terminated. Unfortunately this latter event is too common in batch mating programmes.

Progestagens.

Devices impregnated with a progestagen are placed in the vagina, from where the drug is continuously absorbed. With proper timing, the removal of the devices will leave all animals in the same state — i.e. about to start their next cycle. As with PG injection, the interval from treatment to standing oestrus varies between cows. AB following efficient heat detection will usually produce more conceptions than the more usual mass insemination of all animals at 56 h after device removal. The additional cost and inconvenience of inseminating on detection over two or three days may make this option unattractive. However it should be considered seriously if the amount of oestrous behaviour evident immediately before the 56 h mass insemination does not involve nearly all animals.

The current costs of the devices will usually prevent their use throughout a herd. Even when cheaper products become avilable, recognition of the limitations of the technique will improve the results obtained.

Only if or when devices which supply an oestrogen as well as progesterone are licensed for this purpose will it become possible to treat effectively a whole group of naturally cycling females. For the time being it is recommended that animals which were in oestrus during the week before the device is to be inserted are identified and either treated differently or not at all. This week of heat detection before the devices are inserted also will provide an indication of the level of anoestrus present in the group. If about one-third are seen to cycle during the seven days, then it is usually safe to assume that the group includes few anoestrous members and that the other two-thirds will respond to the devices. If less than 20% cycle during this week of observation, then the reasons should be ascertained — e.g. pregnancy, poor heat detection, abnormalities such as freemartinism, and, of course, anoestrus. Animals due to come out of shallow anoestrus in the near future probably will respond to the devices, however where the anoestrous proportion of a group exceeds 20%, it is likely that the degree of anoestrus is too profound in many of them for this effect to occur.

Most published reports describing the use of these devices in N.Z. refer to beef cattle. Systems have now been designed which allow all classes of cycling females to be considered - cows or heifers, beef or dairy.

System Prog device.

The selected group is monitored for oestrus for at least five, preferably seven, days. Devices are inserted into the remainder (which did not show oestrus) and are removed after 10 to 12 days. Mass insemination at 56 hours after removal or insemination on detection of heat are carried out, depending on the response pattern or ease of management.

The two most attractive options for dealing with the animals which cycled during the pre treatment week would appear to be the following.

(a) Leave them untreated — a number of them will return to oestrus during the period when the treated cows are being inseminated and these can be included in the AB sessions, or

(b) leave them untreated until the day before the devices are to be removed from their treated herd mates. Then they can be injected with PG and expected to cycle during the same period as the others.

Even when devices which supply an oestrogen as well as progesterone are licensed for use as aids in mating management (with all animals treated identically, as one group), at least a week of heat observation will still be an invaluable indicator of the likely response rate.

General comments

The systems described above are examples of the many options available for consideration. Additional systems are being designed and tested as further alternatives which may be even more suitable for some of the many different breeding operations used in the industry. Two most important features are common to all systems and will remain so. These are, (a) the need for careful planning of day by day activities, which is best done with a calendar in hand, and (b) the value of excluding unsuitable animals.

Arrangements with the veterinarian, the semen supplier, the AB technician, etc., must be made well in advance. Cattle will not remain in oestrus while deficiencies in organisation are made good, nor will they respond as well as they could if they are treated on the wrong day. Inseminating facilities should not accelerate inseminator fatigue, and sufficient help must be available so that the technician can confine his activities to doing his job.

Best results with PGs are associated with morning injections and morning inseminations. Other combinations, such as afternoon injections and morning inseminations, tend to increase the number of animals inseminated on two consecutive days, usually because they were just coming into oestrus when first inseminated and were actively ridden for some hours afterwards. This extravaganassociated with the progestagen-releasing devices. It is also far more likely with dry or beef cattle, where the selection of animals to be inseminated is made at the time of insemination, rather than two or more hours beforehand. The dairy farmer rarely presents the same cow for AB on two consecutive days, even though the system of charging adopted by the L.I.A. may not discourage him from doing so.

Relying on tail paint wear as the only indicator of which animals to inseminate is not without risk. Where a high proportion of a group is in behavioural oestrus simultaneously, some will lose little or no tail paint because they are too busy riding to be ridden themselves. Large eartags and adequate time for frequent observations and recording are essential if bulling animals are not be be missed.

Harnessed teaser bulls are not always reliable for the detection and marking of oestrous females. Lameness and illness will become apparent rapidly, however less-obvious problems are not uncommon. Some bulls do not put their chin on the animal they are mating, others are so big and/or vigorous that both parties collapse to the ground, especially with small heifers. In large paddocks, groups of riding females may be more widely scattered than the bull is prepared to travel. Marker bulls should thus be observed closely during the first few days and checked for their enthusiasm and mating ability, so that these attributes are proven rather than assumed. Small, flat paddocks are almost essential for this.

The semen to be used needs careful selection. The finding that a high proportion of the calf crop was by a certain bull, which for an unforseen reason did not meet the required standards, has spoiled at least one highly successful programme. Now that at least one bull has been linked with pregnancies which are, on average, ten days shorter than normal, other bulls with similar powers to disrupt expected calving patterns are sure to be identified.

The different effects of PGs and progestagens on existing pregnancies must not be overlooked. The PGs terminate early pregnancies, the progestagens (without an oestrogen) do not. Therefore the harnessed bull which identifies heat dates before PG treatment need not be vasectomised. However, if progesterone-releasing devices are to be used, all entire bulls should be kept well away. During the interval between PG injection and insemination an entire bull would again be a competitor with the AB technician.

Finally, a few comments on cost. In early 1984 the cost per injection of PG was between $4.50 and $5.00, while the progestagen-releasing devices were about $18.00 each. This difference diminishes when systems which require two doses of PG per animal are used, or if the devices are reinserted for the purpose of synchronising the animals returning to service and protecting some early pregnancies. On the other hand, the use of PGs will lift the normal conception rate of a herd by 10%. No such fertility effect has been found with the intra-vaginal devices. At the moment, reports describing very successful programmes with PGs are far more numerous than those using the progesterone-releasing devices, especially in dry stock and lactating dairy cows.

Examples of oestrous synchronisation in N.Z. herds.

Some examples of results obtained and problems encountered with different systems of oestrous synchronisation are provided on the following pages.

(a) February 1977, Papamoa.

(System PGa — two injections of prostaglandin to each animal, 11 days apart)

Problems. No pre treatment information about cyclicity, pregnancy, freemartinism, etc. — animals to be exported and boat about to leave. All to be inseminated at 72 h and 96 h after the second injection and little time available for heat observation and recording. However, very well grown Friesian heifers, excellent facilities for AB, and an excellent team of technicians.

Results.

612 injected first time — 2 aborted
610 injected second time
607 inseminated twice — 3 abnormal
438 (72.2%) conceived

Comment. Time was the all-important consideration.

Drug (2.8 doses per pregnancy), semen (2.8 inseminations per pregnancy) and inseminating expenses were ignored.

(b) November 1977, Papamoa.

(System PGa)

Problems. As before, but this time with under-weight Jersey heifers and drought feeding. However, same facilities and technicians.

Results.

374 injected first time — 1 aborted
373 injected second time
372 inseminated twice — 1 freemartin
200 (53.7%) conceived

Comment. High incidence of anoestrus (101 of the 372 had no tail paint worn by the time of the second insemination). In fact many remained unmated during the next two months while running with bulls. (3.7 doses of PG, and 3.7 inseminations per pregnancy)

(c) December 1977, Te Kowhai feedlot.

(System PGa)

Problems. 50% of ration was whole maize silage, later found to contain phyto-oestrogens due to mould. However, very well grown Jersey heifers, good facilities and an excellent team of AB technicians.

Results.

414 injected first time — 4 aborted, 2 culled
408 injected second time
404 inseminated twice — 4 freemartins
212 (52.2%) conceived

Comment. The high incidence of oestrous behaviour noticed at the time of first injection was misinterpreted and merely reduced any concern about anoestrus. Many of those conceiving did not remain pregnant and cases of nymphomania and huge udder development were common among those which did not conceive (3.9 doses PG, and 3.8 inseminations per pregnancy, some of which were only temporary).

(d) 1975-78, Paterangi.
(Systems PGa, PGd and PGe)

Between 250 and 280 Friesians and cross-breeds calved each spring. In 1975 System PGa was applied to half of the yearlings (two injections and two sessions of mass insemination). In 1976, 1977 and 1978 System PGd was applied to the yearlings and System PGe to the milking herd.

Usual dates for start of calving were July 1 for heifers and July 10 for the herd. Analyses of milk fat produced showed that animals calving between 21 and 31 July out-produced (to end of January) animals calving in any other test period.

Results. See Table 1 and Table 2.

TABLE 1.
Calving patterns of the Paterangi herd.

No. calving:		Before	August			Sept			After
		July 10	11-20	21-31	1-10	11-20	21-31	1-10	Sept 11
1973	Hfrs	0	2	30	28	17	9	5	9
	Cows	11	9	14	21	17	9	6	13
1974	Hfrs	7	9	32	23	16	3	3	6
	Cows	2	3	13	21	22	11	9	19
1976	Hfrs	0	35	29	6	20	6	4	0
	Cows	0	5	24	19	18	14	6	14
1977	Hfrs	0	0	50	30	11	5	3	1
	Cows	0	0	29	35	17	13	3	3
1978	Hfrs	0	24	33	23	12	0	1	7
	Cows	0	0	14	44	14	8	6	14
1979	Hfrs	0	26	12	30	18	8	5	1
(Projected)	Cows	0	0	18	38	18	16	6	4

TABLE 2.
Milk fat production from the Paterangi herd.

	Length of milking season (days)	Total fat (kg)	Fat to the end of January (kg)	% of total
1973-74	317	39 388	27 493	69.8
74-75	310	38 356	28 409	73.7
75-76	311	37 974	27 761	73.1
76-77	328	39 288	30 928	78.7
77-78	257	35 456	30 138	85.0
78-79	289	29 447	22 925	77.9

Comments. In each of the three years that a PG programme was used with these cows a preliminary culling list was made before mating started. This prevented unnecessary drug and AB expense. Approxi-

THE INDUCTION OF PREMATURE PARTURITION

Introduction

The use of corticosteroids for the treatment of problems in heavily pregnant cows used to be contra-indicated due to the inevitable loss of the pregnancies. However this 'undesirable side-effect' is now the major objective of the use of these drugs in N.Z. The present large-scale usage is likely to increase as the reliability of present methods and the benefits attainable become more widely appreciated.

The initial objective was to eliminate the situation where two distinct groups of calving cows occur in seasonal dairy herds. The last cows to conceive during the previous mating season were induced to calve prematurely and thereby start converting valuable spring feed into milk fat rather than body fat. This objective remains important and is easy to achieve — a bovine pregnancy can be terminated almost at a moment's notice. When used merely as a salvage operation to reduce the length of the calving season, the technique becomes associated with such poor cow and calf survival rates, and infertility in the induced cows, that herd owners become hesitant about using it again. When fully exploited however, the technique can become a major tool for the routine annual management of seasonal herds, and the future will see beef farmers cautiously applying it.

Concentration of the Calving Pattern

Induction of premature parturition in cows can be used to cause the majority to calve in daylight on one selected day. Results from one herd where this has been attempted are shown below.

	No. treated	No. calving at intervals from treatment			
		<24h	25-36h	37-48h	>48h
Te Awamutu 1977	93	14	46	22	11
Te Awamutu 1978	62	9	35	7	1

The improved supervision possible clearly will be of advantage to the weak calves. Those initially too weak to stand and unable to drink often respond beyond expectations to shelter and tube-feeding, and with well-prepared facilities and supplies only the very premature are necessarily hopeless causes. The day of bobby-calf collection may determine the best timing for the induction treatments.

Retained Foetal Membranes (RFM)

Induction of premature calving can reduce the importance and (less successfully) the incidence of retained foetal membranes. Present techniques are always associated with more retained membranes than is normal for full-term calvings in the same herd. However, in the absence of concurrent disease, the problem can be influenced by; (a) cow condition (e.g. 31% of 127 thin cows and 14% of 56 cows of condition score 5 or above had RFM), (b) induction treatment (some regimes result in far more RFM than others), and (c) post calving treatment. Far more cows have RFM than is apparent without internal examination, e.g. 138 cows induced, 42 with obvious RFM and 23 with internal RFM. The cows with internal RFM have a lower incidence of metritis and sub-fertility, possibly due to the absence of a 'wick' of tissue along which pathogens, particularly of faecal origin, gain entry into the uterus. Any external membrane should be cut away (not pulled). Manual removal can be considered five or more days later.

Milk Fat Production

In parturition-induced cows milk fat production can be as good as, or possibly better than, it would have been had the cows calved at full term. Production per day is reduced, but with more days of the lactation on spring feed, total production for the season does not suffer to any extent. This is also evident from the growth rates of calves born prematurely to beef cows (see below).

Subsequent Reproductive Performance

Various factors conspire to reduce the fertility of induced cows. Having calved late, and maybe having retained their foetal membranes, the establishment of normal ovarian activity and uterine environment could be delayed in many cows, perhaps until the third cycle of a mating programme.

Induced cows also are associated with a long return interval to first service, especially when they have not had a pre mating heat. The assumption that they did not conceive is not always correct — such cows are prone to lose pregnancies at or around the normal time for implantation. Induced cows which have not cycled before the start of mating may be best left unmated at their first heat. Prostaglandins can be used to shorten the delay until the next oestrus, at which a higher 'viable conception' rate can be expected.

Following induced calving, submission rate (SR) and conception rate (CR) during the next mating can be high enough, not only for most induced cows to conceive, but also to avoid being induced again the following year.

The following examples support this statement.

(a) The Ruakura No. 2 herd has had 105 cows induced during the last five years. Of these, 91 have conceived with average intervals from calving to first mating and conception of 48 and 67 days respectively, and an average of 1.77 matings per conception. During these days the average number of matings per conception in the rest of the herd (i.e. not induced cows) has ranged from 1.44 to 1.62.

(b) Of 47 Angus cows prematurely induced to calve by an average of 18 days, 42 conceived during the next mating season, and did so only 1 week later on average than 36 untreated cows which had calved (full-term) during the same week. Seven other untreated cows did not conceive.

Timing the induction programme to allow five weeks between calving and mating should be done to improve SR and CR in the early weeks of mating. The value of good condition at calving, and a high level of nutrition thereafter must be emphasised. Continuing to manage the induced cows in a separate group, preferentially fed, may be the best way of undermining the contention that induced cows are automatically of reduced fertility.

Calf Survival

Premature calves can thrive. The interval from the day of the first injection of an induction treatment to the day of calving will vary from little more than a day to beyond two weeks. It will depend not only on how close to full term the cow is, but also on the treatment regime employed. Intervals of more than 12 days are associated with an increase in the proportion of calves born dead or dying. Once the calf is 36 h old and has access to more shelter than is usually provided for full term calves, rearing problems are few. Three pertinent cases are reported below.

(a) (Waikato 1978) On three beef properties 47 cows were induced. These produced 46 live calves which averaged 164 kg at weaning in February. Average weaning weight for 42 calves born full term during the same week was 162 kg.

(b) (Ruakura 1981) Ten Jersey calves with an average birthweight of 21 kg had an average liveweight of 55.2 kg at 8 weeks.

(c) (Ruakura 1982) Five Friesian calves with an average prematurity of 18 days and an average birthweight of 22 kg, had an average liveweight of 50.2 kg at 8 weeks.

The assumption that weak, underweight calves will inevitably die and should therefore be destroyed at birth is unfortunate. Such calves need more care than full term ones and may take longer to reach bobby-calf weights. However, the improved prices received in recent seasons has prompted many farmers to delay destroying induced calves. With colostrum, warmth and good hygiene, many of these calves have been successfully reared, and preparing for this deserves more attention and encouragement from veterinarians.

Planning the Induction Programme

The identity of the cows to be induced must be known months in advance — as early as the previous February, and certainly by weaning or drying off. Similarly the dates for the induced calvings and therefore the dates of treatment, the labour and feed requirements at and before that time, the calf rearing facilities etc., can all be arranged during the winter.

The cows to be induced should be fed to reach a condition score of six when treated, i.e. one score more than the cows calving full term. Cows with problems such as chronic mastitis or facial eczema are excluded as poor risks. Magnesium supplementation can be instituted at least a week before the first treatment.

To improve the subsequent reproductive performance, treatment is timed so that the last cows calve at least five weeks before the first day of the next mating season. With more treatment systems this means that all cows which conceived after the seventh week of the previous mating season will be treated with the first, or priming injection, seven weeks before the next mating season starts.

Induction Technique

In spite of the variety of techniques which have been employed successfully for induction of parturition, there appears to be general agreement on two important points:

(a) that rapid termination of pregnancy increases the chances of undesirable features such as retained placentae and poor production, and

(b) that an interval between first injection and calving of more than 14 days will increase the incidence of stillborn or dull and weak calves, irrespective of their degree of prematurity.

Nearly all the drugs commonly used for induction of parturition fall into the following two categories.

First, the 'primers' which initiate the gradual preparation of the cow and calf for calving by accelerating udder development, changes in the birth canal, and calf maturation. A variety of depot or slow-acting corticosteroids are used for this purpose.

Secondly, the 'triggers' which precipitate the actual calving process —prostaglandins ($F_2\alpha$ and analogues such as cloprostenol), and the more soluble, quick-acting corticosteroids. There is also a betamethasone preparation which is designed to provide both effects.

The choice of actual treatment regime remains a matter for the individual veterinarian and will be based on experience, available information and discussions with colleagues and research workers. It is unlikely that comparative drug costs will play a significant part in dictating which products are used. The recommendations which follow evolved during a series of trials in which a variety of factors that influence the overall success of an induction programme were studied. Only a few of the available products were used. Various dose rates were compared, but in no instances were results improved by straying from label recommendations.

Procedure.

All cows are 'primed' with a depot corticosteriod. The date for this treatment is as close to seven weeks before the first day of the next mating programme as is practicable.

These cows are divided into two categories, based on conception date:

Category A those due to calve within the next three weeks, and
Category B those due after more than three weeks.

Seven days after the first treatment, cows in Category A are inspected. Those with udder development and filling similar to that of a full term cow immediately before calving are treated with cloprostenol. Cows in Category B are unlikely to have fully developed udders by this time. Any

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