# CAN WE IMPROVE REPRODUCTIVE PERFORMANCE IN DAIRY CATTLE?

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**Abstract**

*The successful genetic selection for higher milk production in Holstein cows has nearly doubled the average milk production in the United States since 1960, to over 11,000 kg/year. Over the same time period, there has been a dramatic decline in the reproductive performance of dairy cows. The average number of days open [interval from calving to conception] and the number of services per conception have increased substantially. In order to decrease the longer lactations and the number of cows culled for reproductive reasons it is very important to improve our reproductive management practices. Achievement of optimum herd reproductive performance [calving interval of 12 or 13 months with the first calf born at 24 months of age] requires concentrated management activities especially during the first 100 days following calving.*

*The following management activities are needed to pursue during the early postpartum period to reach or approach the optimal calving interval: careful surveillance and assistance at calving, prevention of post parturient diseases, early diagnosis and treatment of postpartum uterine abnormalities, accurate detection of oestrus, correct timing of insemination, reducing the effect of heat stress and early pregnancy diagnosis.*

**Key words**: dairy cow, dystocia, metabolic disorders, post partum uterine abnormalities, detection of oestrus, timing of insemination, summer heat stress, pregnancy diagnosis

The successful genetic selection for higher milk production in Holstein cows has nearly doubled the average milk production in the United States since 1960, to over 11,000 kg/year. Over the same time period, there has been a dramatic decline in the reproductive performance of dairy cows [19]. The average number of days open [interval from calving to conception] and the number of services per conception have increased substantially [56]. In order to decrease the longer lactations and the number of cows culled for reproductive reasons it is very important to improve our reproductive management practices [55]. Achievement of optimum herd reproductive performance [calving interval of 12 or 13 months with the first calf born at 24 months of age] requires concentrated management activities especially during the first 100 days following calving. Early postpartum breeding of dairy cows results in more calves, and higher milk production per lactation [15]. Poor reproductive performance can reduce the number of calves born and milk production and may increase the cost of therapy and semen.

The following management activities are needed to pursue during the early postpartum period to reach or approach the optimal calving interval: careful surveillance and assistance at calving, prevention of post parturient diseases, early diagnosis and treatment of postpartum uterine abnormalities, accurate detection of oestrus, correct timing of insemination, reducing the effect of heat stress and early pregnancy diagnosis.

**Careful surveillance and assistance at calving**

The most important breeding objectives are to reduce the number of calving assistance required. This is even more important, since calving assistance in itself may result in a shift of the calf's acid-base balance. Therefore, the main emphasis should be paid on the prevention of asphyxia of calves at birth, since instruments suitable for a reliable clearing of respiratory passages and for maintenance of this state and for artificial respiration of calves under practical conditions are not yet widely used [37, 60].

In case of difficult calving, the mode and time of calving assistance should be chosen with regard to profitability factors and in a manner which would allow the least possible shift of the calf's acid-base balance towards acidosis. Before applying traction, measurements of the soft birth canal should always be considered when dilatation of the soft maternal passages is not sufficient they must be expanded non-surgically or surgically (episiotomy lateralis) and obstetric lubricants should be used [60] to avoid tractions longer than 2 to 3 minutes [61] and rib and vertebral fractures due to excessive traction [52].

If a prolonged traction is expected, Caesarean section should be carried out to save the calf and to prevent injuries to the maternal birth canal. Recent studies have shown that before making a decision as to the mode of calving assistance in an animal hospital, the results of acid-base balance measurements from blood samples should be considered [60]. The routine use of complex treatment of calves born with severe asphyxia may reduce the postnatal calf losses [37, 66]. In addition to an adequate therapy, particular attention in the case of calves with asphyxia should be paid to the ingestion of sufficient amounts of colostrum, since the lack of colostrum uptake is accompanied by an increased susceptibility to E. coli infections [11].

While it is not possible to eliminate dystocia, adequate management of heifers during their development (adequate feeding, selection of a sire with a negative expected progeny difference for birth weight) and close observation of cows and heifers during calving are essential for reducing calf losses [30, 66]. It is also very important to avoid birth injuries and infection of the reproductive tract during assistance, which is more likely to occur in cows with dystocia. Dystocia can negatively affect the subsequent pregnancy rate of dams [44].

**Prevention of post parturient diseases**

Dairy cattle are usually in negative energy balance (NEBAL) in the first weeks of lactation because of energy intake during this period is less than half of the energy requirements for milk production. Therefore the gap between energy input and output during early lactation must be met through increased non-esterified fatty acid (NEFA) production. On the other hand energy requirements of dairy cows is met in 60-70% by volatile fatty acids (acetate, propionate and butyrate) fermented in the rumen therefore ruminal fluid is one of the most important source of energy metabolism in the dairy cow. In the periparturient period feed intake is physiologically suppressed which will cause a lack of dietary energy intake resulting in a lack of gluconeogenesis and in turn, a lack of glucose to allow for complete oxidation of NEFA. The incomplete oxidation of fatty acid will contribute to the increased production of ketone bodies (β-hydroxybutyrate /BHB/, acetone, acetoacetate) which may cause ketosis and fatty liver. According to Oetzel [40] two types of ketosis may develop: "Type I ketosis" with low blood glucose due to lack of precursors for gluconeogenesis without fatty liver occurring at 3 to 6 weeks postpartum; "Type II ketosis" associated with fatty liver just before or at calving manifesting 5 to 15 days after calving. Increasing amount of ketone bodies may also contribute to suppress feed intake. Salivation is also decreased during calving due to breaking chewing or reduced period and intensity of chewing. This may contribute to the development of clinical or subclinical rumen acidosis especially when the ration of concentrate is not limited for a few days around calving. Ruminal acidosis may also negatively affect rumen motility and appetite. Similarly according to Geishauser et al. [27] severe hypocalcaemia may be associated with decreased abomasal motility but it is not clear whether this can be generalized to either clinical milk fever or subclinical hypocalcaemia.

As mentioned before a rapid increase in energy requirements at the onset of lactation results in a negative energy balance (NEBAL) that begins a few days before calving and usually reaches its most negative level [nadir] about 2-3 weeks later and used to extend 10-12 weeks until the beginning of the usual breeding period [10, 18]. The NEBAL that develops spontaneously in dairy cows represents a physiological state of undernutrition. The severity and duration of NEBAL is primarily related to differences in dry matter intake and its rate of increase during early lactation. Calving in moderate condition (3-3.75) and maintaining feed intake during periparturient transition period are key factors to reducing NEBAL and avoiding metabolic problems [milk fever, acidosis, ketosis and fat cow syndrome] that are deleterious to performance.

Following parturition, regardless of NEBAL due to elevated plasma FSH concentrations a wave of follicular development starts in 5 to 7 days after calving. Three types of follicular development have been described which are the followings [9]:

1. Ovulation of the first dominant follicle [16-20 days after calving]
2. Non-ovulation of the first dominant follicle followed by turnover and a new follicular wave
3. The dominant follicle fails to ovulate and becomes cystic

The development of non-ovulatory dominant or cystic follicles prolongs the interval for the first ovulation to 40-50 days after calving. Ovulation of a dominant follicle during early lactation depends on the re-establishment of pulsatile LH secretion [20]. The NEBAL as physiological state of undernutrition may suppress pulsatile LH secretion and reduce ovarian responsiveness to LH stimulation and by this way deters ovulation [20, 31].

It is worth mentioning that prolonged anovulatory anoestrous in only 30% of the cows can be connected with reduced fertility caused by NEBAL [46, 59]. It seems that NEBAL can influence the timing of first postpartum ovulation by which it can negatively affect fertility [20, 22]. Cows remaining anovulatory for > 50 days of lactation are less likely to become pregnant during lactation and will be culled [25].

Plasma progesterone (P4) concentrations used to elevate during the first two or three postpartum ovulatory cycles [58, 59, 77]. The rate of increase in P4 is reduced or moderated by NEBAL [58, 77]. At the same time, high dietary intake [both energy and protein] may also increase the metabolic clearance of P4 in high yielding cows [79]. P4 through the regulation of uterine environment plays an important role in conceptus development and growth. A slower rate of increase in P4 after ovulation may decrease the embryo growth by Day 16 and is associated with low fertility [17, 35, 54].

Early postpartum NEBAL may adversely impact quality of oocytes during the first 80-100 days after calving required for follicle development and oocyte development (blastocyst formation rate) which exert another carryover effect on fertility [16, 32].

However, it is very difficult to reconcile the effect of NEBAL on follicles and oocytes with the effect of high dietary energy on oocyte quality and development to blastocysts in dairy cows [5, 13]. It appears that extremes in energy status in either direction may negatively influence fertility [20].

Fertility in dairy cows reflects the cumulative influence of metabolic, endocrine, and postpartum health components. Energy imbalance seems to be one of the most important factors, but the complex interactions of the aforementioned factors can be considered in order to be able to improve fertility [20], at the same time BCS, glucose, NEFA or IGF-1 concentration from calving to AI cannot explain the low fertility rate [56].

Cows should be challenge-fed during dry-off period and early lactation to prevent the incidence of metabolic diseases of the puerperal period such as milk fever, acidosis, ketosis and fat cow syndrome. These diseases can increase the incidence of reproductive diseases and reduce the reproductive performance. Prevention is more preferable to treatment and requires close attention to nutrition and management [44]. The maintenance of good condition at calving and the provision of a high-density energy diet that does not produce a fatty liver in early lactation are also very important to minimize the detrimental effect of NEBAL on the return of oestrous cycle after calving.

**Early diagnosis and treatment of post partum uterine abnormalities**

Cows having dystocia, retained foetal membranes, metabolic disorders (hypocalcaemia), or twins are more likely to contract uterine infections than cows calving normally. Postpartum infection of the uterus has long been considered to have a deleterious effect on subsequent fertility [24]. Thus, nutrition, population density, management of calving [decrease of stress], sanitation during calving, early diagnosis and treatment of uterine infections are of great importance. It is recommended to treat puerperal metritis and clinical endometritis as early and as intensively as possible in order to keep the conception interval short. Recently fresh cow programs have been developed based on monitoring cow temperatures each morning for the first 10 days after calving which allow for early treatment

[12]. However, the results of routine treatment of cows with intrauterine antibiotics (oxytetracycline, neomycin), intrauterine antiseptic chemicals (iodine solution, polyvinylpyrrolidone-iodine solution), systemic antibiotics (penicillin, ceftiofur), or hormones (oxytocin, PGF2a, GnRH, estrogens /prohibited to use in Europe/) after calving are greatly variable or their use[s] is/are controversial [80]. More detailed information about the diagnosis and treatment of post-parturient uterine abnormalities in the cow has been summarized recently [68].

**Accurate detection of oestrus**

Oestrus detection is one of the major contributors to low fertility results in the field [45]. Until recently, it was believed that this was caused by the low input of the farmer, whose priorities were elsewhere on the farm. However, since the study made by Van Vliet and Van Eerdenburg [76], it is clear that cow factors are also part of the cause for low detection rates. One of the management related factors for the low number of standing heats in their studies might be the fact that there was only one cow in heat at the same time. Due to the size of the average dairy herd in several European countries (45 – 50 cows) and the year round calving pattern, the chances of having more than one cow in oestrus at the same time are rather limited. The number of cows in oestrus at the same time is of major influence to the intensity and length of the oestrus [76]. Another point of concern is the short duration of oestrus. In a recent study [76] it was shown that a substantial number of animals (40%) showed oestrous signs for less than 12 h. The mean duration of oestrus was 13.7 h in their study, in which the cows were observed every two hours for 30 min. The short duration of oestrus in the modern dairy farms makes it even more important than before determining correctly the optimum time for insemination [14, 34, 71]. Simple observation of the herd for 30 minutes in the morning before and after milking, at midday, and late in the evening is recommended to determine oestrus accurately under usual management. The use of traditional aids like pressure sensitive mount detectors, tailhead markings, and/or detector animals or recently developed aids like pedometry, electrical resistance measurements, and/or electronic pressure-sensitive mount detectors may improve the accuracy of oestrus detection. The combined use of monitoring of oestrous behaviour and one or more oestrus detection aids may improve its efficiency [53].

It is very important to emphasize when standing heat is used as a predictor for time of ovulation ($26.4 \pm 5.2$ h) only a limited number of cows display standing heat [58%], especially when few animals are in oestrus at the same time. According to a recent study the onset of mounting behaviour displayed in 90% of estruses is the best predictor for time of ovulation ($30.0 \pm 5.1$ h); however its limitation is that it cannot yet be assessed by oestrus detection aids [47].

**Correct timing of insemination**

Using progesterone assay of plasma or milk as an indication of true oestrus, it was clearly demonstrated that 7 to 22% of cows showing oestrus had abnormal level of progesterone when they were inseminated. When such cows are inseminated they do not conceive or it leads to abortion if they had been pregnant [6, 36, 39]. Since the chances for pregnancy after insemination are much higher when ovulation occurs within the survival time of sperm [71] therefore it is important to inseminate the cow about 12 hours after oestrus detection.

In a recent study [75], 100 cows were detected in oestrus with a scoring system. Of these animals, 50% showed standing heat and of the 64 animals that were presented for insemination, 98% did indeed ovulate. There was no correlation between follicular size and ovulation time and oestrus detection score. The level of the milk yield and parity were also not correlated with the oestrous behaviour score. The animals that ovulated 0-24 h after first ultrasonographic examination scored more than twice the number of points than did the ones that ovulated 24 - 48 h after first scanning ($P = 0.045$). Ovulation > 48 h after AI did result in a pregnancy in only 15% of the cows. Cows that do not show overt signs of oestrus and thus score < 100 points in the scoring system used, have a high chance of ovulating after 24 hours and should therefore be inseminated again after 24 h [75].

Ovulation can also be detected by means of ultrasonography, since it is characterised by the abrupt disappearance of the large ovulatory follicle [33, 75]. Pedometers may detect oestrus accurately (83%) and appear to be a promising tool for prediction of ovulation (duration between onset of increased number of steps and ovulation: 29.3±3.9 h; duration between the end of increased number of steps and ovulation: 19.4±4.4 h) in dairy cow [48], while monitoring progesterone alone is not sufficient to predict ovulation [49].

Measurement of viscosity and crystallization of cervical mucus may be related to ovulation time and help to determine the optimal time for AI [73].

Before the beginning of the breeding season in bull-bred herds breeding soundness examinations of the bulls are of great importance to avoid infertility and venereal diseases [44].

Without oestrus detection, synchronization of ovulation can be achieved on the farm by using Ov-Synch (GnRH+PGF2a+GnRH+ timed AI), Co-Synch (GnRH+PGF2a+GnRH and timed AI), or Pre-Synch (PGF2a+ PGF2a+GnRH+PGF2a+GnRH+ timed AI), which provides similar pregnancy rates per AI when compared with those of classical reproductive management systems, based on oestrus detection and hormonal therapy when necessary [43].

When oestrus detection on the farm is good PGF2a treatment and ai at the observed oestrus are recommended, when oestrus detection is poor Ov-Synch, Pre-Synch or Co-Synch and a fixed time AI are recommended [38].

**Reducing the effect of summer heat stress**

Summer heat stress may cause elevated core temperature, decreased appetite and dry matter intake which can impair fertility in lactating dairy cows through reducing duration and intensity of oestrus, altering estradiol concentration and follicular dynamics, reducing preovulatory surge of LH and luteal function and milk yield. Oocyte quality and early embryonic development may also be compromised. Some discrepancies can be found in the literature regarding the changes of progesterone concentrations in the blood during oestrus cycle due to summer heat stress because increased, decreased or no effect on progesterone concentrations were reported [21, 28].

As multifactorial mechanisms can be found in the backgrounds of decreased fertility during heat stress and their effects may vary depending on the magnitude of heat stress therefore it is very important to understand the homeorhetic process which governing the acclimation to thermal stress is under endocrine control. According to Collier et al. [21] "the process of acclimation occurs in two phases (acute and chronic) and involves changes in secretion rate of hormones as well as receptor populations in target tissues". These changes may improve the resistance to heat stress in dairy cow however it needs weeks rather than days to complete the whole process.

Successful cooling strategies for lactating dairy cows such as shades, holding-pen -, exit-lane- and free-stall cooling with sprinkler and fan cooling system, or evaporative cooling system in arid climates are based on maximizing available routs of heat exchange, convection, conduction, radiation, and evaporation [21, 28] and can contribute to the improvement of reproductive performance. However, large declines in fertility rate may still occur during periods of hot weather [26]. To overcome the poor oestrus detection rate due to reduced duration and intensity of oestrus during heat stress TAI programs (OvSynch) are used intensively, however the incidence of high embryonic mortality may limit its use. By cooling during the immediate post breeding period and using embryo transfer pregnancy rates can be improved however further developments in the techniques for in vitro production of embryos, embryo freezing, and timed embryo transfer are needed [28].

Correlation between the metabolism of free radicals and antioxidants during heat stress is not completely understood. However, Trout el al. [72] has clearly demonstrated that heat stress had no effect on the production of malondialdehyde, or the concentration of α-tocopherol, β-carotene, retinol, or retinyl palmitate. At the same time long-term feeding of supplemental β-carotene increased the pregnancy rate (35% versus 21%) for cows calving in Florida from May 2 to August 5 [3], while short-term β-carotene treatment at Day -6 to 0 before expected oestrus did not improve fertility [4]. Feeding supplemental niacin has a positive effect on milk yield, feed intake and perhaps increasing heat loss through the cutaneous vasculature [57]. At the same time it is very important to alleviate the summer fertility by the provision of high quality forage and feed to overcome negative energy balance [23].

Genetic selection for resistance to heat stress would be an alternative of the above mentioned methods however to reduce effects of environment on dairy cows that are genetically adapted to hot climates needs long-term efforts. Another solution is to indentify specific genes (coat colour, hair length) that control traits related to resistance to heat stress [28].

**Early pregnancy diagnosis**

Accurate early detection of pregnant and non-pregnant cows as well as cows with late embryonic mortality plays a key role in the achievement of an optimal calving to conception interval.

One of the most recent techniques for diagnosis of early pregnancy in cattle on the farm is B-mode ultrasonography. Under field conditions, acceptable results may be achieved with ultrasonography [using 5 or 7.5 MHz transducers] from Days 25 to 30 [29, 42, 50, 61, 63, 64, 67]. The reliability of the test greatly depends on the frequency of the transducer used, the skill of the surgeon [7], the criterion used for a positive pregnancy diagnosis [61] and the position of the uterus in the pelvic inlet [62]. More incorrect non-pregnancy diagnoses were made in cows between Days 24 to 38 in which the uterus was located far cranial to the pelvic inlet, in comparison with cows in which the uterus was located within or close to the pelvic inlet [62].

In a recent study, some non-pregnant cows could already be recognised by the absence of a corpus luteum at the first ultrasonographic examination on Day 20 or 21 after AI. With the exception of one cow, every non-pregnant cow was correctly diagnosed by Day 29 or 30. False negative pregnancy diagnoses on Day 29 or 30 may be corrected, if the cow with a non-pregnancy diagnosis in the presence of a corpus luteum on Day 29 or 30 after AI was re-examined 3 to 4 days later. Three to four ultrasound examinations may be beneficial for optimal calving to conception intervals under field conditions [65].

It was also demonstrated that pregnancy testing by means of transrectal ultrasonography [8, 65] or transrectal palpation [69] as soon as possible after Day 30 could result in shorter calving intervals. Rectal manipulation of the uterus (palpation of uterine fluctuation, palpation of amniotic vesicle or palpation of the foetal membrane slip) may increase the risk of embryonic death [1, 26, 70, 78]. However, other research has not been able to confirm the iatrogenic effect of rectal palpation [41, 51, 74]. Recently, the effect of the membrane slip technique on foetal loss was controlled by a non-invasive method (PSPB RIA test, conceptus proteins). No significant difference was found between the control group and the palpated group therefore it was concluded, that embryonic mortality was not caused by rectal palpation. However, it was not possible to distinguish embryonic mortality caused by rectal palpation from spontaneous embryonic loss that may occur in non-palpated cows [2].

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