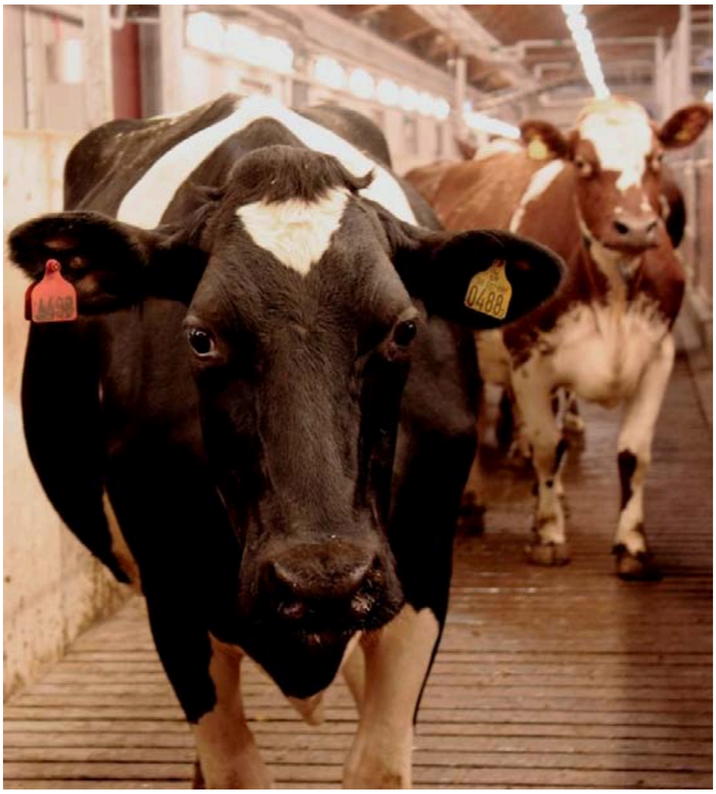
Swedish University of Agricultural Sciences
Faculty of Veterinary Medicine and Animal Science

Fertility before and after installation of Herd Navigator™

Matilda Birgersson



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Fruktsamhet före och efter installation av Herd Navigator™

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Abstract

The fertility of dairy cows is of great importance in order to maintain high production. The decline in fertility of dairy cows the latest decades can have several explanations. The large emphasis on high yielding cows and the negative genetic correlation between milk production and fertility traits could be one of the main factors for impaired fertility. To find heats and inseminate the cow at the right time is crucial to receive high conception rate. Delaval has, in corporation with FOSS, developed Herd Navigator which is a management program that measure four biological parameters in the milk; progesterone, betahydroxybutyrate, lactate dehydrogenase and urea. In this study the focus will be on progesterone which is a hormone produced by the corpus luteum. The concentration of this hormone indicates where the cow is in her estrus cycle.

The study was performed on three Swedish and three Dutch farms where the parameters for fertility were compared one year before and one year after the installation of Herd Navigator. Calving interval, number of inseminations per pregnancy, conception rate, open days and days from calving to first insemination were analyzed. Unfortunately several inseminations were found to be missing in the data set before the installation of Herd Navigator. The fertility measures based on number of inseminations were therefore not reliable; however calving dates seemed to be complete reported. No significant differences in open days and calving interval before and after the installation of Herd Navigator could be found in this study. However, a significant reduction in number of days from calving to first insemination could be seen. There was also a tendency of a shorter calving interval on the Swedish farms after the installation. To get additional information of the practical experiences of Herd Navigator an interview with the farmers was made. They found that the measurements of progesterone were very helpful and time saving in order to find heats. It would be interesting to implement further and more comprehensive studies on a larger data set that include all inseminations. Moreover, it would be interesting to see what impact continuous measurements of progesterone will have on the reproduction performance.

Sammanfattning

Fruktsamheten hos mjölkkor är av stor betydelse för att upprätthålla hög mjölkproduktion. De senaste årtiondena har fruktsamheten inom mjölkproduktion försämrats vilket kan ha flera förklaringar. Alltför stor vikt på avkastning i avelsmålet och den negativa genetiska korrelationen med fruktsamhet kan nämnas som en bidragande orsak. Att hitta brunster och seminera vid rätt tidpunkt är avgörande för att få korna dräktiga. Delaval har i samarbete med FOSS utvecklat Herd Navigator som är ett managementprogram vars uppgift är att underlätta skötseln av korna för lantbrukaren. Fyra biologiska parametrar mäts i mjölken; progesteron, betahydroxybuturat, laktatdehydrogenas och urea. I denna studie ligger fokuset på hormonet progesteron som produceras av gulkroppen och vars nivåer kan ge en indikation om var kon befinner sig i brunstcykeln. Studien genomfördes på basis av data på tre svenska och tre holländska gårdar där fruktsamhetsparametrar jämfördes ett år innan installationen och ett år efter installationen av Herd Navigator. Kalvningsintervall, antal insemineringar per dräktighet, dräktighetsprocent, tomdagar och antal dagar från kalvning till första inseminering

var de parametrar som analyserades. Då information om en stor andel insemineringar saknades i datamaterialet innan installationen av Herd Navigator, kan analyserna av de fruktsamhetsmått som baseras på antalet inseminationer inte bedömas som tillförlitliga. Inga signifikanta skillnader i tomdagar eller kalvningsintervall kunde påvisas före och efter installation av Herd Navigator. Däremot kunde en signifikant reduktion i antalet dagar från kalvning till första inseminering ses. Dessutom kunde en tendens till kortare kalvningsinterval noteras hos de Svenska gårdarna efter att Herd Navigator installerades. I samband med studien gjordes också en intervju med de lantbrukarna som har programmet installerat. De uppgav att mätningarna av progesteron var till stor hjälp för att hitta brunster och att det sparade dem mycket tid. Det vore intressant att genomföra vidare studier på ett större datamaterial där alla insemineringar fanns rapporterade för att se hur fruktsamhetsmåtten påverkas av kontinuerliga progesteronmätningar.

Introduction

Dairy cow fertility has declined worldwide the latest decades. In Sweden the interval from first to last artificial insemination increased from 33 days in 2000/2001 to 38 days in 2010/2011 (Swedish Dairy Association, 2012). The number of inseminations per cow has increased from 1.7 to 1.8 and the calving interval from 13.1 to 13.3 months. Impaired fertility is the most common reason for culling and according to the Swedish dairy association 23 percent of the cows were culled due to fertility problems in 2010/2011. The decline in fertility may result from several different reasons (Veerkamp *et al.,* 2000). Too much emphasis on high yielding cows in the breeding goal and the negative genetic correlation with milk yield could be a possible explanation. Failure in detection of heat could be another major reason for impaired fertility. Not enough time spent on estrus detection, high yielding or low ranking cows that do not show visible signs of heat are probably the main reasons for this failure (Veerkamp *et al.,* 2000).

DeLaval, in corporation with FOSS, has developed a new management program called Herd Navigator, HN (Delaval & FOSS, 2010). The idea with the program is to facilitate and improve the production in the dairy industry. To inseminate a cow at the right time can be difficult and therefore Herd Navigator could be an important tool that enables insemination at the right time, even though the cow does not show clear signs of heat. Herd Navigator use continuous measurements of progesterone to determine reproductive status and detection of heat. Follicular cysts and luteal cysts lead to low respectively high concentrations of progesterone. Based on this, Herd Navigator can give indications of cysts as well as heat, pregnancies and abortions. In addition to progesterone, the program also registers betahydroxybutyrate and urea to give a measure of the cow's energy balance and the balance between protein and energy in the feed ration. To detect mastitis at an early stage, a fourth parameter is measured, lactate dehydrogenase. This parameter is used for detecting mastitis before any deviation in the milk can be seen (Delaval & FOSS, 2010).

Progesterone has traditionally been used for diagnosing reproduction disorders and for following up treatments, e.g. if a cow is treated for ovarian or luteal cysts (Persson *et al*., 2009). Progesterone has however not been used as much as it could have been because of high labor input and problems with identity security when many samples are taken simultaneously. Another explanation for the infrequent use of progesterone measurements could be the difficulties with interpretation of sporadic sampling. Herd Navigator takes repeated samples automatically and could, by using biological models, give alarms to the farmer. It also enables the farmer to simply read and interpret the results. Herd Navigator facilitates progesterone measurements and could therefore diagnose disorders in addition to heat detection. The facilitating of heat detection will presumably be one of the most important functions of the program (Persson *et al*., 2009).

The strength of estrus behavior in dairy cows has decreased over the years; one explanation could be the improved milk production and the stress of being a high yielding cow (Boer *et* *al.,* 2010). It could therefore be difficult to detect heat even when the cow has normal estrus cycles. According to Friggens & Chagunda (2005) the use of endocrine parameters for predicting reproductive status could be a possibility to improve the fertility. Petersson *et al*. (2008) found that the accuracy to predict cows with delayed cyclicity was high when progesterone was measured two to three times per week which is suitable for inline progesterone measurements. It was also concluded that progesterone measurements are good markers for both early start of luteal activity and delayed cyclicity post partum. In addition, selection based on results from progesterone analysis could ensure dairy cows with earlier start of luteal activity (Petersson *et al*., 2007). Several articles indicate that repeated progesterone measurements evaluated by a biological model had the potential to be an important reproduction tool in the future (Friggens & Chagunda, 2005; Saint-Dizier & Chastant-Maillard, 2012)

Aim and objective

Herd Navigator has been installed on commercial farms since 2009 and today 67 farms all over the world use the program. The objective of this study was to evaluate how the fertility is affected after installation of Herd Navigator by comparing fertility parameters one year before and one year after the installation. Three Swedish and three Dutch farms were included in the study and the objective was to determine the impact HN has had on their reproduction management. The regular frequent progesterone measurements were investigated to see if they could facilitate the heat detection for the farmer and if this could result in better fertility results.

Literature review

Herd Navigator

Herd Navigator has been developed during 2000s by the Danish development company Lattec I/S in cooperation with DeLaval and is now on the market in Denmark, Netherlands and Sweden (Blom & Ridder, 2010). The biological models in the program decide before each milking session which parameters that should be analyzed from the cow (Mazeris, 2010*)*. A representative sample is taken and depending on if the cow is milked by an AMS (automatic milking system) or in a parlour the amount varies between 30 and 80 ml (personal communication R. Cosin, February 2013). The milk samples are collected in a sample intake unit and sent one by one to the analyzing unit. This unit is connected to a computer where the herd staff can read the results, if a cow is in heat an alarm can be seen on the screen (Asmussen, 2010). For all new information supplied to the computer, Herd Navigator does a new assessment of the available information. The intention is to do a classification of the status of the cow and calculate when the next sample should be taken (Persson *et al*., 2009).

The samples are taken with different intervals depending on which stage in the estrus cycle the cow is in (Delaval & FOSS, 2011). The first heat is normally not used for insemination and is difficult to detect by the progesterone curve because of constant low concentration after calving. However, the model detect when progesterone level goes from low to high levels and will then record that a heat has occurred and will thereafter look for a new heat around 21 days later. After a heat, the program will take samples around day 5, 9 and 14 to detect follicular cysts. After day 18, more regular tests will be taken with the intention to find the next estrus. Usually Herd Navigator starts taking samples 20 days before the voluntary waiting period ends, to be able to find the first heat, target for insemination (Delaval & FOSS, 2011). With help from progesterone measurements, even silent heats could be detected and cows with postpartum anestrus and cysts could be identified at an early stage which hopefully can lead to a reduction in number of open days (Asmussen, 2010).

The heat alarm is based on the change of the progesterone curve, which in turn is based on the samples taken during the estrus cycle (Persson *et al*., 2009). To increase the accuracy of the assessment, individual calculations of the progesterone levels are made continuously by HN. The heat alarm is an indication of the proestrus, the decline in progesterone begins about 12 hours before any signs of heat could be detected. After the alarm, it takes approximately 2.5 days before the ovulation occurs. The recommendation is therefore to inseminate about 1.5 days after the heat alarm. Each time Herd Navigator gives an alarm of estrus, the program calculates the probability for pregnancy if the cow is inseminated. This probability is based on an estimation of the quality of the egg and the uterus at the moment for insemination. The quality of the egg and uterus is assessed by the shape of the progesterone curve, the energy balance of the cow and the level of urea in the milk (Persson *et al*., 2009). In figure 1 the approximate time between heat alarm and the biological processes during estrus is shown.

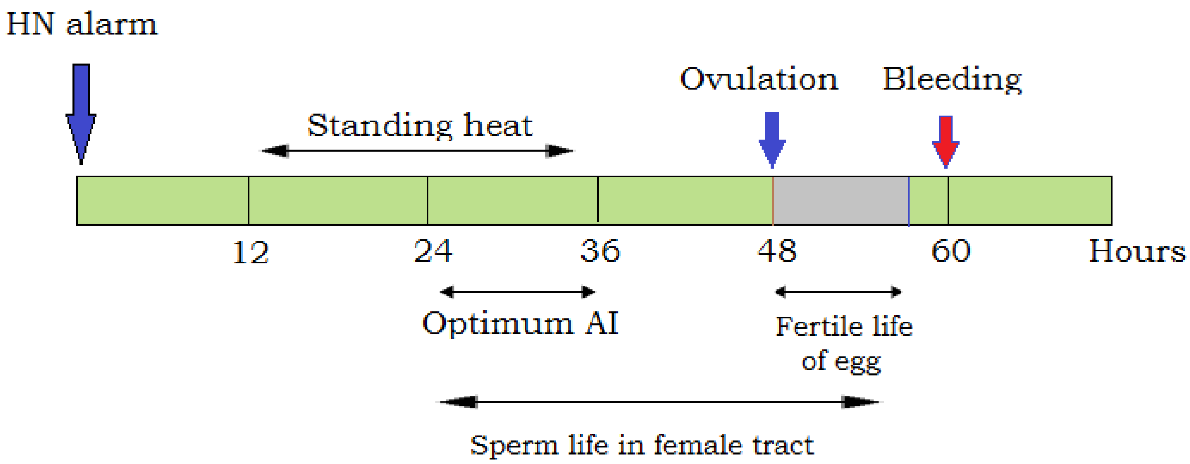

Figure 1. Optimal time for insemination in relation to Herd Navigator alarm (Modified from DeLaval & FOSS 2010).

Except heat detection, the idea with continuous measurements of progesterone is to make a progesterone profile from where it is possible to receive more information (Blom & Ridder, 2010). The profile enables the program to give alarms if the cow does not return to normal cyclicity after calving or if she seems to have a follicular or luteal cyst. It will also be possible to exclude the gestation survey because it can be assessed by the levels and changes in progesterone concentration if the cow is pregnant or not (Blom & Ridder, 2010). Depending on the stage of the estrus cycle, Herd Navigator adjusts the number of assays taken from the cow, in average six to seven progesterone assays are taken per estrus (Friggens & Chagunda, 2005). To get a better view over the variation in progesterone concentration a smoothed curve is used and from this has the algorithm for classifying the cows into three categories been developed. The categories are; **status 0**: post partum anestrus, **status 1**: estrus cycling and **status 2**: potentially pregnant (Persson *et al.*, 2009). The cows are automatically divided into these categories depending on their progesterone profile.

One of the main causes of declined fertility is the difficulty of finding cows in heat. However it has been shown that the estrus detection rates could differ significantly between different herds (Sawyer *et al.*, 1986). Sawyer *et al.* (1986) observed an average heat detection rate of 77 percent and Roriea *et al.* (2002) found that 50-70 percent of the estruses were detected when only visual observations were used. This could be compared to about 95-97 percent of the heats found with help from Herd Navigator according to Blom & Ridder (2010), Asmussen (2010) and Mazeris (2010). A small study, including three Danish herds, evaluated Herd Navigator with regard to fertility and the result from that study can be seen in *Table 1* (Blom & Ridder, 2010). Conception rate is defined as number of pregnant cows per number of inseminations and differ a lot between the herds in the study. According to Blom & Ridder (2010) this could be explained by different strategies for reproduction. For example; herd 3 had a technician that performed the inseminations while the inseminations in herd 1 and 2 were performed by the staff on the farm.

Table 1. Heat detection rate and conception rate in herds with Herd Navigator (modified from Blom & Ridder, 2010).

	Herd 1	Herd 2	Herd 3
Number of cows	124	201	143
Heat detection rate, %	97	95	97
Conception rate, %	63	55	40

Progesterone

Progesterone is produced by the corpus luteum in the ovary and the concentration varies depending on sexual phase and the stage of the estrous cycle (Persson *et al*., 2009). The first period after calving, the concentration of progesterone is low but after the first ovulation it rises and thereafter forms a cyclical pattern, see figure 1. The cow's estrus cycle is on average around 21 days and the progesterone level is low for about five days during estrus. The level is then high for the remaining 16 days between two estruses. The concentration of progesterone can vary between 0 to 50 ng/ml. In Herd Navigator the threshold value between the follicular phase and the luteal phase is set to 4ng/ml (Persson *et al*., 2009).

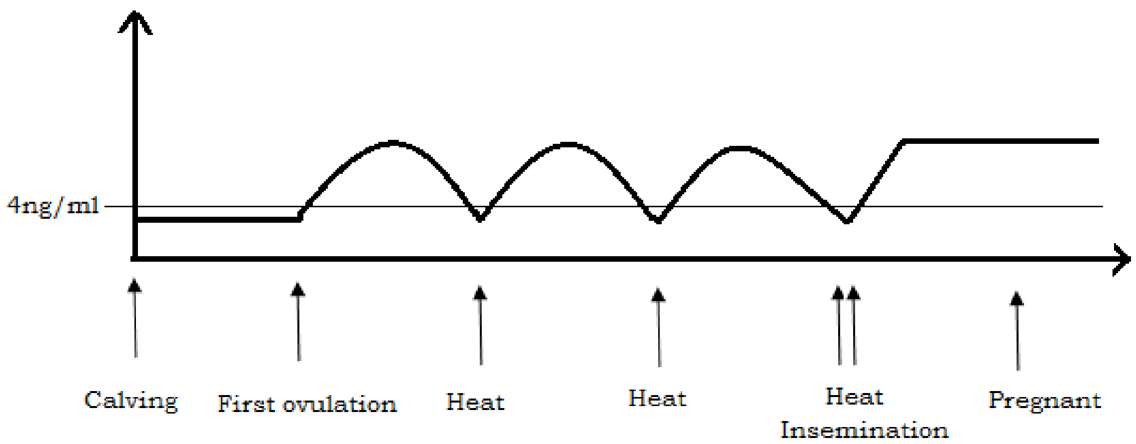

Figure 2. Schematic picture of a normal progesterone curve from calving to confirmed pregnancy (Modified from Persson et al., 2009).

In a non-pregnant cow, the endometrium release prostaglandin F2α on day 18 after ovulation, which leads to lyses of the corpus luteum (Saint-Dizier & Chastant-Maillard, 2012). This in turn leads to a decrease of progesterone in the blood followed by preparations for a new estrous cycle. Since the concentration of progesterone in blood correlate with the concentration in milk, it is possible to measure the progesterone level in the milk (Roelofs *et al.,* 2006). On average the progesterone declines below 5ng/ml 80 hours before ovulation but there could be a large variation between cows when the decline in progesterone occurs (Roelofs *et al.,* 2006). In figure 3, a progesterone curve from HN is shown. In the beginning of the curve, the cow is pregnant and therefore the progesterone level is high. The first blue spot is the time for calving. Then the progesterone concentration declines two times due to estrus. On the second estrus the cow was inseminated (the second blue spot) and became pregnant why the progesterone level thereafter remain constant high.

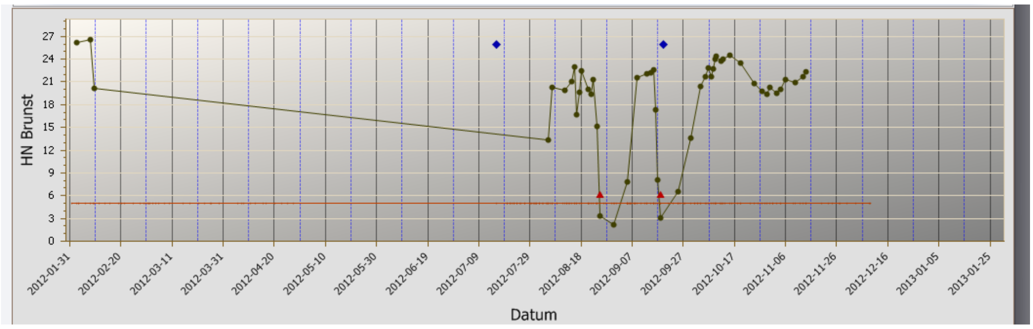

Figure 3. Progesterone curve from HN. When the cow is pregnant the progesterone level is constant high. After calving, the cow starts to cycle and on the first insemination (at the second spot) she got pregnant. This can be seen on the high progesterone level in the end of the curve.

Friggens *et al*. (2008) performed a study analyzing how well the progesterone profile was consistent with the estrus cycle. They found that out of 121 confirmed estruses (which were defined as estruses that resulted in pregnancy after insemination), 104 were associated with a decrease of progesterone below 4ng/ml. With a progesterone threshold of 6ng/ml, 120 of the 121 confirmed estruses could be discovered by progesterone profile. About 99 percent of the confirmed heats could thereby be detected by the model. The conclusion of the study was that progesterone measurements is the most sensitive system for heat detection compared to visual detection and to use of activity meters (Friggens *et al*., 2008).

Other advantages with progesterone profile data could be pregnancy confirmation and information of the luteal activity. According to Friggens *et al*. (2008), the sensitivity to predict if the cow is pregnant or not based on the progesterone level was 89.3 percent. Faustini *et al*. (2007) reported that 98.2 percent of the pregnancies could be determined by progesterone measurements. Studies have shown that number of days when the sensitivity is calculated may influence the results. The different numbers that have been reported in the studies can therefore be explained by different days after the insemination when the calculations were made. Romano *et al*. (2006) reported that the sensitivity increased if the calculations were made further away in time from the insemination compared to when the sensitivity was calculated early after the insemination. The high sensitivity of pregnancy checks can result in both time and money saved for the farmer because the gestation survey could be dispensed.

Economy

Failure in heat detection is a great problem for the fertility result and for the maintenance of high milk production (Delaval & Foss, 2011). It could also affect the economy due to more expenditure on inseminations and prolonged calving interval. Research has shown that about 15 percent of inseminated cows are not in heat, which results in unnecessary costs for semen and labor (O’Connor, 1993). A short calving interval is usually mentioned as a key factor for profitable production and depending on milk price and feed costs, the economic loss can vary. An extended calving interval from 12.5 to 13.5 months has been shown to result in a loss of about $35 and $45 per cow and year (O'Connor, 1993). According to Delaval & Foss (2011) the cost per open day after the voluntary waiting period is about 2€ due to extended calving interval and additional expenditure for semen.

Reproduction

The reproduction efficiency of dairy cows has declined over the world and the rapidly increased milk production is believed to be one of the major causes (Thatcher *et al*., 2006). Besides milk production, increasing herd size, less labor on the farms and higher inbreeding coefficient could be possible reasons for the impaired fertility. The genetic selection has mainly been focused on high yielding cows and as a consequence the emphasis on fertility traits has been low. This has lead to increased time from calving to first ovulation, lower concentrations of progesterone in the blood and higher frequencies of anestrus and abnormal luteal phases. Also the number of twin births and incidence of embryonic death has increased (Thatcher *et al*., 2006). To reduce this problem, people that work with dairy production need to cooperate and develop new strategies and add sufficient emphasis on fertility traits in the breeding goal (Thatcher *et al*., 2006).

To inseminate at the right time is of great importance in order to receive a pregnant cow (Roelofs *et al.,* 2005). If the insemination takes place too early there is a risk of getting an aged sperm before the ovulation. On the other hand, a too late insemination could decrease the probability for fertilization due to an aged egg. However there could be a large variation in time for a successful insemination which may be explained by individual differences and variations in heat detection strategy.

During the post partum period it is important to avoid a severe negative energy balance and gynecological diseases because they could lead to increased risk for extended anestrus postpartum and prolonged calving interval as a consequence (Butler, 2003). Cows in moderate body condition had the best fertility and are most likely to become pregnant according to Pryce *et al*. (2001). It is therefore of great importance to avoid a too high or low body condition score at calving and to prevent diseases that often lead to a rapid decrease in body condition (Ingvartsen, 2006).

Disease could often impair the fertility and many disorders are predisposing factors for severe negative energy balance. This could in turn be explained by the lowering of the feed intake that diseases often result in. Cows with a severe negative energy balance could be very difficult to get pregnant as a result of a delay of the luteal activity post partum, therefore it is essential to prevent negative energy balance (Ingvartsen, 2006). It has also been shown that cows with considerable difficulties to supply their needs of energy often have a lower percentage of fat in the milk in the beginning of lactation (De Vries &Veerkamp, 2000). This could in addition to Herd Navigators measurements of betahydroxybutyrate, be an indication of the cow's energy status and also a sign of her possibilities to get pregnant as well as the risk for delayed ovarian activity.

There are several tools and methods for detection of heat on the dairy farms. One of the most used tools are activity meters that measure the physical activity of the cow which increase two to four times when she is in heat (Diskin & Sreenan, 2000). In a study by Løvendahl & Chagunda (2010) it was shown that activity meters were an effective tool in order to find heat. It was also concluded that there was a concordance between progesterone concentrations and the cow's activity. In addition, they discussed that activity meters could be a good complement to progesterone measurements to find the right time for insemination.

The duration of estrus could differ between cows due to individual differences and yield level. Yoshida & Nakao (2005) concluded that the signs before standing heat last for about 9.6 ± 8.1 hours and the duration of standing estrus were in average 6.6 ± 6.3 hours. To inseminate the cow during standing heat increase the possibilities of pregnancy. The cow is most likely to get pregnant during standing heat, it is therefore recommended to inseminate at this time (Yoshida & Nakao, 2005). According to Roelofs *et al.* (2005) standing for mounting is the best sign in order to predict time for ovulation. This behavior is more difficult to assess compared to mounting behavior which could be detected, for example by the use of mounting detectors.

Follicular and luteal cysts

Cysts are one of the main causes to impaired reproduction in dairy cows and they could have a considerable negative impact on the economy due to an increased number of open days and a prolonged calving interval (Silvia *et al*., 2002). Ovarian follicular cysts are formed when one or several follicles do not ovulate normally but instead continues to grow (Vanholder *et al*., 2006). To be defined as a cyst the follicle has to be at least 17 mm in diameter and last for more than 6 days (Silvia *et al*., 2002). According to another definition the follicle have to be at least 25 mm and last for a minimum of ten days (Vanholder *et al*., 2006). To define the follicle as a cyst it is also required that no luteal tissue is found by ultrasonic scanning (Hamilton *et al*., 1995).

Cysts could be classified as a multifactorial disorder and it is believed that both genotypic and environmental factors could affect the prevalence (Vanholder *et al*., 2006). A defect in the hypothalamus, pituitary or in the follicle could also be contributing factors to the development of a cyst. However, endocrine imbalance has been suggested to be one of the main reasons for development of cysts. The persistence of the cyst is dependent on the absence of a corpus luteum (Garverick, 1997). The problems are most common in early lactation when the cow goes from no cyclicity to a regular estrus cycle. In average a cyst remains for about 13 days (Vanholder *et al*., 2006; Hamilton *et al*., 1995).

Cysts can be divided into follicular and luteal cysts but are considered to be the same disorder but in different stages. Luteal cysts are assumed to be a later stage of follicular cysts (Vanholder *et al*., 2006). By measuring progesterone, a distinction between the cysts could be made. Follicular cysts secrete no or only small amounts of progesterone while the luteal cysts secrete more. The threshold value of progesterone between follicular and luteal cysts could be difficult to establish according to the literature. In Herd Navigator the length of the follicular and the luteal phase are continuously recorded, and if the normal length of the phases is exceeded the system gives an alarm (Persson *et al*., 2009). After calving it is normal for the cow to have an extended follicular phase but it could also be a sign of follicular cysts if she does not resume her normal cyclicity. On the other hand, if the luteal phase is longer than expected there is a considerable risk for a luteal cyst. Similarly to the alarm for follicular cysts, Herd Navigator gives an indication when the progesterone level has been on the same level for a longer period than normal (Persson *et al*., 2009).

Halter *et al*. (2003) concluded in their study that about two thirds of the cows with ovarian follicular cysts had a moderate concentration of progesterone when the cysts were found. Only one third of the cows get a low concentration of progesterone. This could make the diagnosing difficult if only progesterone is used as basis for decision (Halter *et al*., 2003). Caroll *et al*. (1990) concluded that there was variability in progesterone concentrations between cows with ovarian cysts. Their study showed that cows with luteal cysts sometimes had a very low concentration of progesterone, occasionally below 1ng/ml. But due to presence of a corpus luteum cows with follicular cysts sometimes could have high progesterone level as well. To detect cysts could be difficult and no method is always accurate. Therefore it is of great importance to verify that the cows return to normal cyclicity after adequate treatment (Caroll *et al*., 1990).

About 10 to 13 % of the dairy cows are affected by ovarian follicular cysts (Garverick, 1997). An older study has indicated that there could be a cost of about $137 per lactation for a cow with follicular cyst due to reduced milk production and veterinary expenses (Bartlett *et al*., 1986). According to Garverick (1987), cysts could be successfully treated with hormones; about 80 % of the affected cows could recover by using GnRH (gonadotropin releasing hormone).

Material and methods

Data

The data in this study has been retrieved from three Swedish and three Dutch farms. All farms in the study have had Herd Navigator running for at least one year. Completeness of data was one of the most important criteria when prioritizing among available farms. The data comes from DeLaval´s management program Delpro, in which the farmers register events such as inseminations, calvings and treatments. The data from Delpro was extracted into an Excel file where also the time of calving and inseminations were noted. For each cow the dates for different events were extracted from Delpro to Excel, one year before and one year after the installation of Herd Navigator. A statistical analysis of the material was performed by using the data from Delpro, processed in Excel. The fertility parameters were analyzed both before and after the installation in order to enable a comparison.

The material before installation of Herd Navigator for the six herds consisted of data from 360 cows except for calving interval where 358 registrations were made. The corresponding numbers after HN installation were registrations from 714 cows and on 494 cows for calving interval (Table 2).

The farms included in the study

The herd size of the studied farms varied between 100 and 300 cows, all six farms had loose housing system and robotic milking by a VMS™ (voluntary milking system). Most of the cows were Holstein but also some Swedish Red. The feeding system was TMR (total mixed ration) on four farms but some concentrates were given to the cows in the robot or feeding stations. The two other farms had silage and concentrates separated from each other where the concentrates were given both in feeding stations and in the robot. The average milk yield differed quite a lot between the farms, from 8200 kg up to 11000 kg milk per cow and year.

Lactations in which inseminations were reported both before and after the date for installations of HN were removed from the dataset. Likewise cows that were mated with a bull were removed. Cows missing two dates for calving due to current pregnancy were used however, to calculate the other fertility parameters (except calving interval). Open days and conception rate could only be calculated on confirmed pregnant cows, therefore only pregnancy checked cows were included in the data.

In order to get a general overview of the management routines of the farms some questions were asked to the farmers. The voluntary waiting period (i.e. when the farmers start to inseminate after calving) differed a bit between the farms but around 60 days were most common. One farm started insemination after just 45 days and two farmers reported that they wait for up to 100 days for the highest yielding cows. None of the farms had changed voluntary waiting period since Herd Navigator was installed and none of the farms used heat synchronization. On all farms the inseminations were mainly performed by the farmer himself or by the farm staff.

Variables

Calculations were made in Excel by using the event dates from Delpro. The variables used were calving interval, time from calving to first insemination, open days, inseminations per pregnancy and conception rate. Calving to first insemination and calving interval was calculated as the days from calving to the first insemination and to the next calving respectively. Open days were calculated as the number of days from calving to the day for the last insemination, in other words, the number of days when the cows are not pregnant. Conception rate was calculated by dividing the number of inseminations with the number of pregnancies they resulted in. Some abbreviations are used; CI –Calving Interval, IPP –Inseminations Per Pregnancy, OD –Open Days, CTFI –Calving To First Insemination, CR –Conception Rate.

Statistical analysis

The data from Delpro was analyzed with SAS 9.3 -statistical analysis system. The Univariate procedure was used to study the distribution of the registrations. The Means procedure and the Anova procedure was used to describe the material and test if there were any statistical differences between the fertility parameters before and after HN was installed.

Results

Experiences from the farmers

All farmers except one reported that they spent less time on estrus detection since Herd Navigator was installed. The other farmer said that they were spending the same amount of time on estrus detection as before the installation.

The Swedish farmers declared that they usually confirm heat alarms with visual signs of heat. On the other hand, the Dutch famers said that they commonly not confirm heat alarms but if they see a cow in standing heat it resulted in an earlier insemination. All farmers agreed on that the heat alarm generally came short before the visual signs could be seen. On the Dutch farms inseminations were made even when visual signs of heat were not observed. In Sweden, the farmers only in exceptional cases inseminated without signs of heat.

All farmers had the opinion that it was much easier to find heats with help from Herd Navigator and most of them also said that it facilitate the assessment of the right time for insemination. Two farmers reported that it could be difficult to know the right time for insemination due to long time between two milkings. The long milking interval lead to a longer time between progesterone sampling which in turn makes it more difficult to know when the decline in progesterone occur. Only one farm used activity meters as an additional tool for finding heats and according to the farmer it was easier to know the right time for insemination with the additional help from the activity meters. Three farms still used pregnancy checks while the other farms only relied to the progesterone curve.

Statistical analysis of the data material

The data from the six herds were analyzed both pooled together and each one separately. Table 2 shows the fertility parameters before and after Herd Navigator was installed. Five fertility measures were analyzed, calculated from reported calving and inseminations dates. Unfortunately not all inseminations dates were found in the material before HN was installed and most often only the insemination that resulted in pregnancy was found. The poor data quality before installation of HN, especially for the fertility measures based on inseminations, means that the comparisons using insemination dates has to be interpreted with caution.

The average calving interval before HN installation was 404 days±63 days and after HN installation it was 405 days±60 days.

Number of days from calving to first insemination was significantly reduced after HN was installed.

Table 2. Fertility measurements from six herds before (blue) and after (white) Herd Navigator was installed. The abbreviations used; CI-Calving Interval, IPP-Inseminations Per Pregnancy, OD-Open Days, CTFI-Calving To First Insemination, CR-Conception Rate.

Variable	N Before	N After	Mean Before	Mean After	SD Before	SD After	Min Before	Min After	Max Before	Max After
CI (days)	358	494	404	405	63	60	308	304	670	648
IPP (nr)	360	714	1.37	2.20	0.89	1.44	1	1	7	10
OD (days)	360	714	124	126	63	62	23	24	404	381
CTFI (days)	360	714	109	86	54	32	23	22	372	249
CR (%)	360	714	88	64	25	32	14	10	100	100

Diagram 1 shows the distribution of calving intervals for the six herds. The largest proportion of cows had a calving interval of about 380 days both before and after Herd Navigator was installed. There were no greater differences in the distribution of calving intervals.

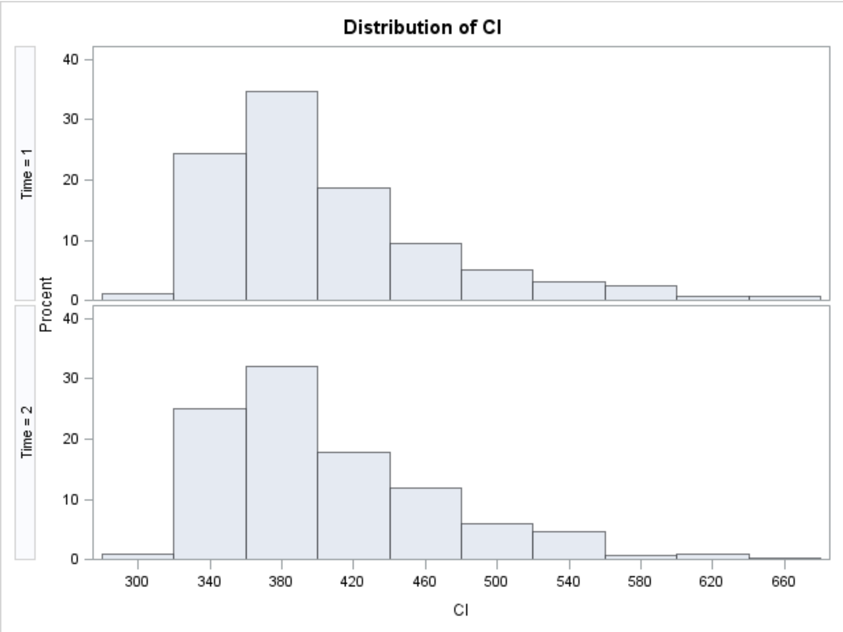

Diagram 1. The distribution in percent of different calving interval in days, before (time 1) and after (time 2) Herd Navigator was installed in six Swedish and Dutch herds.

Diagram 2 shows the distribution of calving to first insemination (CTFI) in the six herds. Before HN installation the largest proportion of cows had a CTFI of about 90 days compared with approximately 60 days after the installation. The mean CTFI before was 109 days and after 86 days.

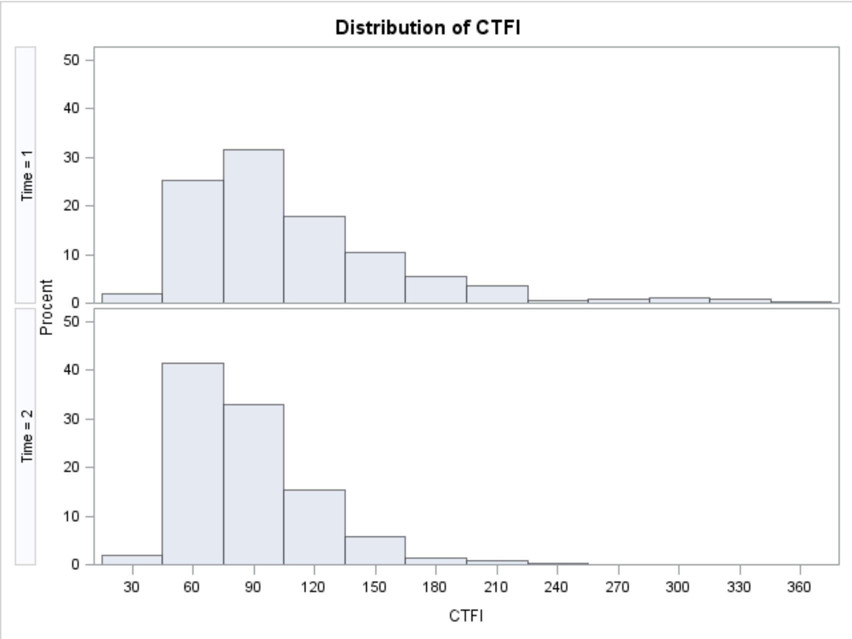

Diagram 2. The distribution in percent of number of days from calving to first insemination before and after Herd Navigator was installed in six Swedish and Dutch herds.

Diagram 3 illustrates how the variation in open days changed before and after HN. Most of the cows were open for about 80 days both before and after the installation and there was no significant difference between the two groups.

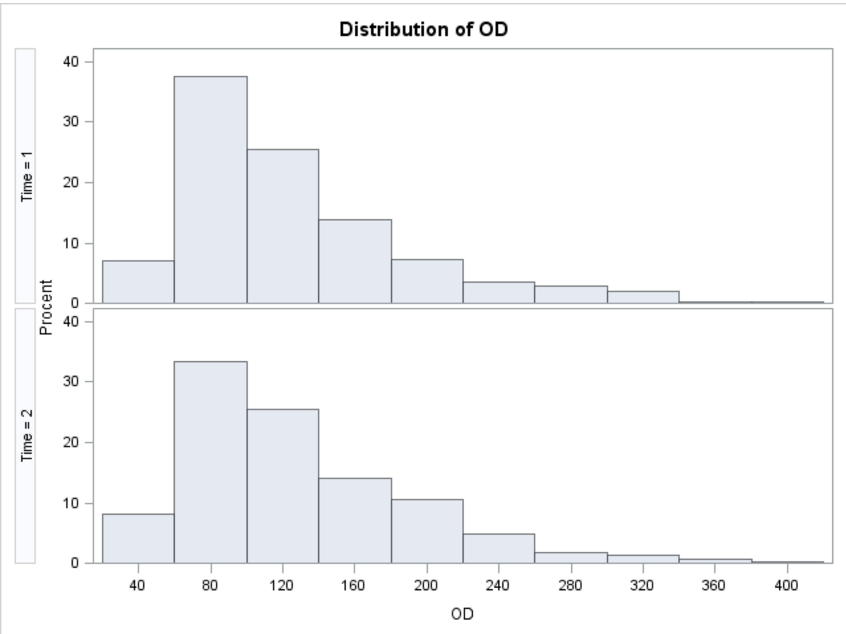

Diagram 3. The distribution in percent, of number of open days before and after Herd Navigator was installed in six Swedish and Dutch herds.

According to the statistics from the Swedish Dairy Association (2012) the average calving interval for cows affiliated to the official milk recording scheme is 399 days. In the Netherlands the corresponding figure is 417 days (CRV Jaarstatistieken, 2011). In table 3 and 4 it can be seen that the calving interval of the Swedish farms after HN installation was

397±57 days and on the Dutch farms 412±62 days. Number of inseminations per pregnancy after HN installation was 2.24± 1.49 in Swedish herds and 2.15±1.37 in Dutch farms.

Table 3. Fertility measurements from the three Swedish herds before (blue) and after (white) Herd Navigator was installed. The abbreviations stands for; CI-Calving Interval, IPP-Inseminations Per Pregnancy, OD-Open Days, CTFI-Calving To First Insemination, CR-Conception Rate.

Variable	N Before	N After	Mean Before	Mean After	SD Before	SD After	Min Before	Min After	Max Before	Max After
CI (days)	235	245	400	397	60	57	313	317	651	629
IPP (nr)	236	381	1.31	2.24	0.74	1.49	1	1	5	8
OD (days)	236	381	121	122	60	61	35	27	372	360
CTFI (days)	236	381	107	81	53	30	35	27	372	249
CR (%)	236	381	89	63	23	33	20	13	100	100

Table 4. Fertility measurements from the three Dutch herds before (blue) and after (white) Herd Navigator was installed. The abbreviations stands for; CI-Calving Interval, IPP-Inseminations Per Pregnancy, OD-Open Days, CTFI-Calving To First Insemination, CR-Conception Rate.

Variable	N Before	N After	Mean Before	Mean After	SD Before	SD After	Min Before	Min After	Max Before	Max After
CI (days)	123	249	412	412	68	62	308	304	670	648
IPP (nr)	124	333	1.48	2.15	1.11	1.37	1	1	7	10
OD (days)	124	333	130	131	69	63	23	24	404	381
CTFI (days)	124	333	113	91	56	33	23	22	335	243
CR (%)	124	333	85	64	27	32	14	10	1	1

Discussion

Due to missing dates for insemination before the installation of Herd Navigator, it was not possible to do a fair comparison of all the fertility parameters. As insemination dates were missing, the conception rate was not reliable estimated before the installation of Herd Navigator. On the other hand, the calvings and the insemination that result in pregnancy seemed to be documented and it was therefore possible to evaluate how the calving interval and number of open days had changed when progesterone was used as a tool for finding heats.

The number of days from calving to first insemination seemed to be significantly reduced in some farms when Herd Navigator was installed. But this could also be a result of missing dates for inseminations before HN installation. Often, just the insemination that resulted in pregnancy was included in the data material and that insemination is often not equal to the first insemination. However there could be reasons for earlier inseminations when information from progesterone could give an indication of heat i.e. after HN installation.

In early lactation when the cow is high yielding, she needs to mobilize energy from her own body reserves to maintain the production. During this period the cow is less likely to show obvious heats due to negative energy balance and that could be one reason for silent heats. With help from progesterone measurements there is an opportunity to see these silent heats and inseminate the cow if the cow has passed the target for voluntary waiting period. However, there was no significant difference in number of open days in this study. A lower number of open days could be expected if earlier inseminations are made and perhaps this could be seen in the future when HN has been running on the farms for a longer time.

According to the farmers that have Herd Navigator it is a very good tool for finding heats. The heat detection rates that the farmers have experienced are in line with the high heat detection percentage that Blom & Ridder (2010) received in their study. However, two farmers in the present study reported that it could be difficult to know the right time for insemination due to long intervals between progesterone sampling. Another explanation could be that there is a great variation between cows when the progesterone decreases and thereby when the heat alarm goes off (Roelofs *et al.,* 2006). Activity meters and visual signs of heat are a good complement to the progesterone curve which could facilitate the decision when the optimum time for insemination takes place. Perhaps some improvement in the program could be made in the future that simplifies the decision of right time for insemination which most likely would lead to a higher conception rate.

It is recommended to inseminate the cow 1.5 days after Herd Navigator has given an alarm. According to Persson *et al*. (2009) the decline in progesterone occurs about 12 hours before any signs of heat can be seen even though there might be individual variation. If the cow show the first signs of heat, such as mounting other cows, or have clear mucus 12 hours after the alarm, it might be too early to inseminate her just 6 hours later. According to Yoshida & Nakao (2005) an average cow shows the first estrus signs about 9.6 ± 8.1 hours before the standing heat and the standing heat lasts for around 6.6 ± 6.3 hours. Roelofts *et al*. (2005) found in their study that the ovulation generally takes place 30 hours after the onset of estrus. This means that the ovulation occurs about 42 hours after the alarm from Herd Navigator which can be compared with 60 hours according to Persson *et a*l. (2009). It could be discussed whether inseminations 36 hours after the alarm is optimal or not. A study that compare conception rate of cows with different times for inseminations would be interesting.

The variation in conception rate that have been seen in this study and also was reported by Blom and Ridder (2010) could have several explanations. Some farmers do the inseminations by themselves and could thereby to a large extent control the time of insemination. Perhaps technicians have more experience and perform a better insemination, on the other hand it could be more difficult to inseminate at right time when an appointment need to be booked in advance.

The Swedish dairy association (2012) reported that the average calving interval (based on Swedish cows affiliated to the official milk recording scheme) was 399 days. That agrees well with the result from the Swedish farms before the installation of Herd Navigator which had an average calving interval of 400 days. After the installation a slightly improvement could be seen where the calving interval was 397 days. On the Dutch farms the average calving interval according to, CRV Jaarstatistieken (2012), was 417 days. This could be compared with 412 days on the Dutch farms included in the present study, both before and after Herd Navigator was installed. It means that both the Swedish and Dutch farms had a shorter calving interval after the installation of HN compared to the reported official statistics from each country.

With help from progesterone measurements it is possible to find heats in cows that only show very weak signs or no signs of heat at all. It could therefore be an opportunity to keep cows that are difficult to get pregnant for a longer time. Perhaps these cows will get more inseminations before a decision of culling is made. This means that it could be an increased calving interval of some cows after installation of HN because the cows get more chances for pregnancy. In this study there was no increase in calving interval after HN installation which might be explained with that many cows got pregnant on early inseminations.

The quality of the data varied between the six farms. Several events before Herd Navigator was installed were missing in the data. In most cases only the insemination that resulted in pregnancy was documented. However the data quality was much better after the installation. Unfortunately, heats that not were target for insemination were missing. Therefore a fair analysis and comparison of heat detection, inseminations per pregnancy and conception rate was not possible.

According to the farmers it is much easier to find heats and the regular estrus checks could be reduced in time after having HN installed. The majority of the farmers said that only the cows that have a heat alarm from Herd Navigator were targets for their visual checks of heats. That could lead to much saved time which probably will be a considerable economic advantage with progesterone measurements compared to visual estrus detection. In addition the progesterone curve could be a tool for finding the right time for insemination. It could also be expected that the saved time will increase in the future due to the fact that the farmers probably will rely more to HN when they have used it for a longer time. Herd Navigator has not been running for such a long time on any farms, so it could be anticipated that a longer time would be needed before improvements could be seen.

In big herds many different persons can be in charge of the inseminations. This could lead to a wide-range of pregnancy results as some persons are more skilled than others. The use of AI-technician could also affect the conception rate to a large extent. According to statistics from the Swedish farms the conception rate differs between 28 percent up to almost 100 percent depending on the person that performed the insemination. It is also relevant to consider that different persons may inseminate at different times and that there could be a variation how good they are at assessing signs of heat.

Conclusions

According to the farmers Herd Navigator is an invaluable tool for finding heats but unfortunately this could not be analyzed properly in this study due to missing data before HN was installed. The farmers also said that HN saved them time as visual heat checks takes considerable more time compared to the automatic heat alarms that comes from HN.

A tendency to shorter calving interval was seen on the Swedish farms after HN was installed. This could be seen as an indication, in strengthening the opinion of the famers that HN is a good tool for finding heats. It should also be mentioned that the calving intervals in both the Swedish and Dutch farms were somewhat lower than the average according to the milk recording scheme for the respective country.

The data quality after the installation was much better compared to before. It seems like the data quality changed to the better during the recent years at least for the herds with Herd Navigator. Further and more comprehensive studies, using a larger data material, are needed to see how the fertility can be affected by using Herd Navigator. Studies of the right time for inseminations would also be interesting.

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