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Puerperium in the modern dairy cow: state of the art

Puerpério na vaca leiteira: estado da arte

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Abstract

The present article aims to 'translate' the current – mostly theoretical – knowledge on fertility disorders in modern high yielding dairy cows, towards the actual situation in the stable with a main emphasis on the resumption of the ovarian activity after calving. While some detailed research has recently been done at our department to elucidate the association between a high level of milk production and the reproductive performance of the current dairy cow, the next challenge is to 'translate' this knowledge into practice and to offer possibilities and strategies to minimize the effects of the decrease in fertility. As the negative energy balance and general health status after calving are known to be paramount factors hampering fertility, it is apparent that avoiding both is among the most important preventive measures to be taken. Improvement of the energy status by achieving a high dry matter intake and the provision of optimal and well balanced nutrition during the transition period as well as during early lactation are key goals in this effort. To achieve these goals, we should not only calculate the rations on paper, but should also check in the stable to determine whether the calculated amount is really being consumed by the cows. Furthermore, veterinarians should use their 'clinical eyes' as well as other diagnostic tools to assess the general health status of the cows and to assess at which aspect of the process things are going wrong and need to be adjusted. Besides the control of the negative energy balance and health status, other management factors that need to be maximized include heat detection, cow comfort, insemination technique, time of insemination during estrus and sperm quality. Only if management is on a very high level can high milk production and good fertility be a feasible combination!

Keywords: dairy cow, milk production, reproductive disorders, management.
Palavras-chave*: vaca leiteira, produção de leite, problemas reprodutivos, manejo.*

Introduction

Before milk production starts, cows have to calve and each calving is followed by a milk production peak. This standard 'cow knowledge' clearly illustrates why reproduction is still of paramount importance in the modern dairy industry.

Recent studies both in the US as well as in Europe have indicated that in the last 35 years, the genetic potential for milk production in Holstein Friesian cows has increased by over 3000 kg per lactation, resulting in an actual genetic increase of about 100 kg/year. This is, however, only a part of the (success) story. The genetic potential for milk production sets the upper limit which an individual cow can achieve. How close she actually comes to reaching that limit is determined by the management conditions under which she has to produce.

During the last decades these conditions have been improved tremendously. There have been improvements in feeding practices, in the control and prevention of diseases and in other management practices such as housing. All together these improvements have contributed to the actual level of milk production, which on many farms has gone above 9000 kg per lactation (of 305 days).

Clearly, the aggressive genetic selection together with the fine tuning of the management has proven to be very successful. However, this has not been without costs. When dairy farmers are currently asked what the principal health problems will be that their business will face in the near future, they invariably mention subfertility, mastitis and lameness. These diseases are known to be multifactorial and to a large extent dependent on management practices.

High yielding dairy cows produce well but reproduce bad

The time period characterized by the steep increase in milk production, is unfortunately also characterized by a dramatic decline in reproductive performance. Both the average number of days open (interval from calving to the next conception) and the number of services per conception have increased substantially, while the conception rate has declined significantly (Lucy, 2001, Leroy and de Kruif, 2006)

Worldwide, calving rates to first service are reported to have declined from 60% to 30-40% over the past 25 years. If this trend continues at its current rate, in a further 20 years only 20% of cows will conceive to first service. This conclusion has been confirmed independently in the UK (Royal *et al.*, 2000 a, b) and in the US (Butler, 2000), and subsequently in many other European countries.

Also in Flanders and The Netherlands, the increase in milk production per cow has been accompanied by a significant increase in the calving interval, from 395 days in 1987 to 419 days in 2007 while the 56 day non-return rate has remained relatively stable (Opsomer *et al.,* 2006 a, b; de Kruif *et al.,* 2008). Analyses of fertility data from local AI centres revealed that the prolongation of the calving interval was mainly due to a prolongation of the interval from parturition to first insemination, due to the inability of the farmers seeing their cows in heat at the moment they should inseminate them (Opsomer *et al.,* 2000b).

The main negative results of this decline in fertility are longer and hence 'inefficient' lactations and an increase in the number of cows that are culled for reproductive reasons. The significant waste of sperm and the retarded increase of young stock are also important contributors to a significant loss of income.

So why has reproductive performance declined so precipitously? This has proven to be a very difficult question to answer (Vanholder *et al.,* 2006). However, a recurring theme is that for cows to reproduce successfully, a clean and healthy uterine environment is essential. Indeed, the uterus not only influences the resumption of normal ovarian cyclicity to a large extent, but also has to promote sperm transport and finally has to undergo considerable changes to support pregnancy.

The dilemma of the postpartum cow

A remarkable feature of cattle is the almost constant bacterial contamination of the uterine lumen within the first 2 weeks after parturition. However, cows have always been considered to be highly efficient in clearing this contamination, in contrast for example to horses. Present-day, high-yielding dairy cows obviously have more problems and do not quite live up to this reputation. As a result, we now see more cows with puerperal problems, such as retained placenta, acute metritis, abnormal vaginal discharge. (Table 1).

Table 1. Average incidence of puerperal disturbances on 9 high-yielding dairy herds in Belgium (Opsomer *et al*., 200a)

Puerperal disturbance	Incidence (n=463)
• abnormal calvings	16%
• retained placenta	18%
• acute (endo)metritis	15%
• abn vag discharge	15%
• perivaginitis	5%

Although it is very difficult to compare these data with those from earlier studies because of possible (historical) differences in the use of the terms 'endometritis' and 'metritis', it is clear that the overall incidence of uterine diseases in high yielding dairy cows has increased over time (Table 2). Besides the recurrent discussion about the definition of the words 'endometritis' and 'metritis', this large variation is also due to the differences in the diagnostic methods used to classify uterine infections. The use of modern techniques such as ultrasonography and the examination of endometrial aspirates for presence of inflammatory cells has obviously caused a steep increase in the reported incidence of endometritis.

Table 2. Evidence of an increasing trend in the incidence of (endo)metritis based on an extensive literature review.

Endometritis incidence	Year of the study	Authors
• 11%	1968	Tennant and Peddicord, 1968
• 10%	1977	Bouters and Vandeplassche, 1977
• 38%	1983	Oltenacu *et al*., 1983
• 37%	1984	Markusfeld, 1984
• 20%	1986	Whitmore and Anderson, 1986
• 17% (clin) + 37% (subclin)	2002	LeBlanc *et al*., 2002 and Kasimanickam *et al*., 2004
• 53%	2005	Gilbert *et al*., 2005

Throughout the years however, authors always have agreed that the incidence of chronic endometritis (=localised infection of the superficial lining of the uterus occurring >3 weeks after calving), is significantly dependent on the incidence of acute metritis (= infection of the uterine cavity, and of the deeper layers of the uterus causing a sometimes life threatening disease shortly after calving). There is general agreement nowadays that up to 40% of animals have metritis within the first two weeks of calving and that in 10-15% of these animals infection persists for at least another three weeks causing the chronic uterine disease called endometritis (Sheldon and Dobson, 2004).

As uterine inflammation occurs in all cows during uterine involution, the factors responsible for failure to resolve the endometrial inflammation at the start of the breeding period seem to be critical. The latter clearly emphasizes the need to detect and treat animals suffering from endometritis, efficiently and as soon as possible to avoid problems later on. On the average dairy farm however, disease detection is done by the veterinarian, but typically only during routine herd health checks. This means that in many cases, early warning signs of disease go unnoticed until such time that the disease is in its full clinical stage and becomes much more difficult to treat. As a result chronic endometritis may still be present at the moment cows should become pregnant.

Cows affected by retained placenta and/or acute metritis are furthermore at a significantly higher risk of other typical 'dairy cow diseases' as acetonaemia, left displaced abomasum and cystic ovarian disease. Large scale studies based on both American and European data showed, for example, that cows with retained placenta are 2.2 times more at risk of left displaced abomasum and 6.0 times more at risk of developing metritis. Metritis itself causes cows to be 2.0 times more at risk of ketosis; and ketosis makes cows significantly more sensitive to cystic ovarian disease and left displaced abomasum. Although there are some differences in the final numbers published among the different studies, there is an overall agreement that retained placenta and/or acute postpartum metritis is often, if not always, the key element in the disease history of recently calved high yielding dairy cows (Curtis *et al.*, 1985; Correa *et al.*, 1993; Peeler *et al.*, 1994).

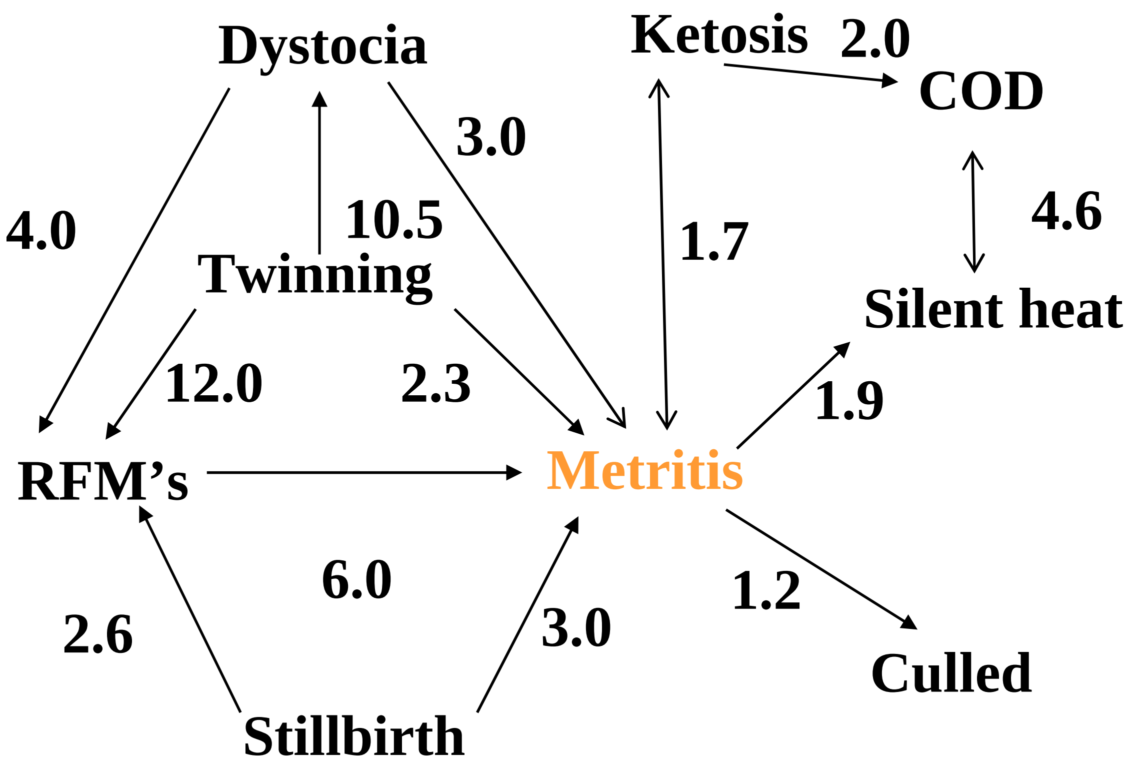

Figure 1. Results of risk factor analyses (odds ratios) for different postpartal diseases in high yielding dairy cows and underlying interactions. RFM= retained fetal membranes. COD= cystic ovarian disease

Although these relationships are clearly proven in large scale epidemiological studies, the underlying pathogenesis has not yet been fully elucidated. In a number of studies it has been demonstrated that the killing activity of neutrophils in high-yielding dairy cows is significantly reduced around the time of calving (Hoeben *et al.*, 2000; Fig. 2). This was further confirmed by *in vitro* studies in which a decreased killing activity of these cells was demonstrated when elevated amounts of ketone bodies were added to the culture medium. This finding probably explains the close relationship between infectious diseases and ketosis seen on present-day dairy herds.

Furthermore it has recently been shown that cows going off feed, is one of the most important risk factors for a left displaced abomasum after calving (Van Winden *et al.*, 2003). In this case, the rumen is not able to act as a physical barrier against the gas filled enlarged abomasum which is hence able to change place in the abdomen. Cows suffering from acute metritis after calving have a distinct decrease in dry matter intake, which might explain the remarkably high incidence of left displaced abomasum in these patients.

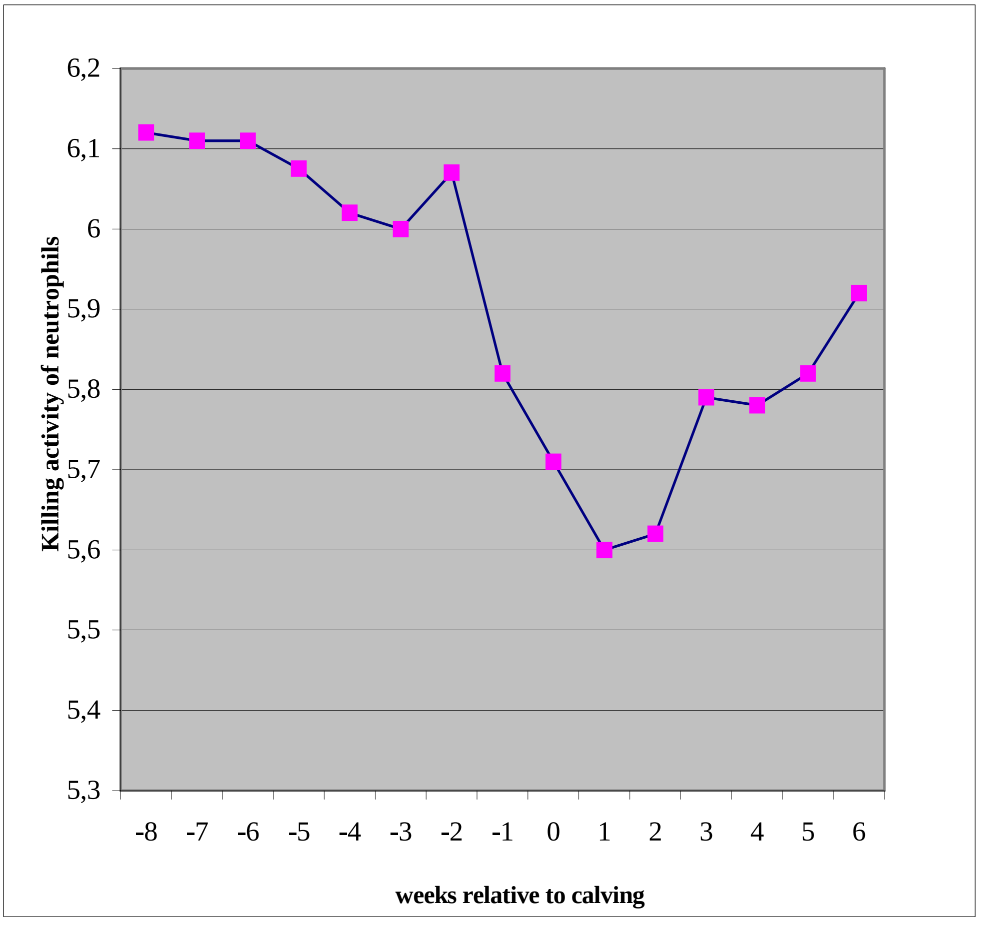

Figure 2. Killing activity of neutrophils around calving.

A bad start usually ends up in a lot of costly troubles

Greater uterine bacterial contamination is associated with reduced ovarian follicular growth and function. Late resumption of regular ovarian cyclicity after parturition has, of course, long-term consequences for subsequent fertility. A comparison of ovarian activity in moderate yielding (4000-5000 kg milk per lactation) Friesian cows fed mainly grass and grass silage in Ireland (Fagan and Roche, 1986), versus Belgian Holsteins producing 8000 to 9000 kg milk per lactation and fed high amounts of concentrates (Opsomer *et al.*, 1998), revealed interesting differences. The Belgian cows not only had an increased number of puerperal disorders, but also a significantly elevated incidence of postpartum anoestrus, abnormal ovarian cycles and prolonged luteal phases (high progesterone for >20 days before breeding; Table 3).

Table 3. A comparison of postpartum reproductive parameters based on measurement of progesterone in milk twice weekly in two different studies using moderate yielding Friesians (Fagan and Roche, 1986) or high-yielding Holsteins (Opsomer *et al.*, 1998).

Results of studies based on prog analysis	Traditional herds (Fagan and Roche 1986)	High-yielding herds (Opsomer *et al.* 1998)
No. of cycles	• 448	• 463
Normal cyclical patterns (%)	• 78	• 53
Delayed cyclicity (%)	• 7	• 21
Temporary cessation of cyclicity (%)	• 3	• 3
Prolonged luteal phase (%)	• 3	• 20
Short cycles (%)	• 4	• 0,5
Other irregular patterns (%)	• 4	• 2,5

Large scale progesterone monitoring projects carried out in the UK over the last 30 years, have confirmed these striking data. Furthermore, a high number of puerperal disorders is significantly associated with an elevated number of postpartum aberrations of ovarian cyclicity, leading to an increased number of cows not seen in heat at the moment farmers should inseminate them.

Overt infection of the uterus will not only influence ovarian cyclicity (Sheldon *et al.*, 2002), but also disrupt the establishment of pregnancy, both by the physiological presence of pus, as well by altered immune responses that are essential at the interface between the endometrium and the embryo. In this context, we can refer to cows discharging small amounts of pus in their mucus around the time of oestrus and insemination. While these cows are not clinically ill, they need veterinary attention be-cause they may often end up as repeat breeders. Although it is quite obvious that pus reflects the presence of bacterial infection, in the majority of cases these small amounts of pus are just the remainders of the neutrophils which cleaned the uterus of bacterial contamination.

Based on the above it is clear that difficulties during calving (dystocia), and immediately there after (e.g. retained placenta) predispose cows to endometritis and subfertility. Hence, all authors agree that the calculation of the total costs associated with uterine infections consists of a composition of both direct (such as treatment costs and the direct decrease in milk production), and indirect costs (such as increased number of inseminations, prolongation of the calving interval and increased culling rate). That's why depending on the source, calculated losses caused by puerperal disorders and endometritis vary between 160 to 420 euro per case.

Although a lot of authors mention that cows with puerperal disorders are at a significantly higher risk of other diseases, such as left displaced abomasum and ketosis, studies focusing on economic losses caused by endometritis often do not mention this. Therefore, it is clear that the figures mentioned are a serious underestimation of the real losses farmers have to face.

Negative energy balance

As NEB seems to be the ever-returning enemy of good fertility in high yielding dairy herds, the basic strategy to reduce the reproductive decline should definitely focus on keeping the NEB under control. While in modern dairy cows genetic progress in terms of milk yield has outstripped that for intake capacity, a certain degree of NEB is inevitable, certainly in early lactation (Thomas *et al.*, 1999). The extent of the NEB (both in depth as well as in duration) varies with the magnitude and rate of increase of milk yield compared to energy intake, however, and thus can be exacerbated if metabolic conditions, disease, housing or management practices impair nutrient intake.

Hence, management strategies by which the effect of a NEB can be limited must be targeted towards increasing nutrient intakes, especially energy. Immediately after calving, the paramount goal should be to maximize energy intake without disturbing rumen fermentation. The first aim of the management of a recently calved dairy cow is to optimize her general health status. Only when optimal health – including an excellent appetite – is achieved, can the focus shift towards achieving an optimal production level. In practice, in their enthusiasm to reach top production levels, farmers often forget this basic principle.

To optimize energy intake, all the while assuring optimal rumen fermentation, the intake of high quality forages in early lactation should be maximized. Once this has been achieved, the energy density of the ration may be increased by gradually raising the amount of concentrates. Generally, under Belgian circumstances, the maximum amount of concentrates given should not exceed 12 kg (9 kg in first lactation animals) and should only be reached at 3 weeks after calving (Opsomer *et al.*, 2004). Increasing the amount of concentrates too fast may disturb ruminal fermentation, which in turn may give rise to ruminal acidosis and an increased incidence of left abomasal displacement.

Currently a lot of research is going on to study the effect of changing the proportion of the different ingredients of the ration. Increasing the amount of fat to maximize the energy content of the ration and hence the energy intake by the animal (Mattos *et al.*, 2000), or increasing the amount of glucogenic substances to temper the steep insulin decrease around the moment of calving (Gong *et al.*, 2002) are excellent illustrations of such measures. For example, the ratio of n6:n3 fatty acids provided in the diet can influence the synthesis of the 2-series of prostaglandins, which are desirable after calving to speed up uterine involution, but undesirable after insemination as they can contribute to the breakdown of the corpus luteum of pregnancy. Hence, the practical implementation of our current knowledge needs to be a better timing of the introduction of rumen protected fats into the diet in accordance with the reproductive stage of the cow. Although primary results seem to be promising, these studies need further confirmation before definite conclusions can be drawn and the results transferred into practical recommendations.

Nutrient or dry matter intake is highly dependent on a lot of factors related both to the cow and to the environment. Among the cow factors, the general health status and body condition score are of major importance. Hence, transition cow programs should focus on maximizing general health and appetite and striving for the ideal body condition score of 3.5 (on 5-point scale) at calving. Aiming for optimal general health includes trimming of the claws at drying off, optimizing rumen health and avoiding metabolic and infectious diseases around calving. Besides this, the veterinarian should provide his herds with a specifically designed standard operating procedure for detecting ill cows as soon as possible and treating them properly.

Furthermore, efforts must be made to remove any environmental restrictions to feed intake, as the environment must be conducive to high intake. Cows need time and space for undisturbed feeding and rumination. There is clear evidence now that the design of food passages, barriers, troughs for water supply and cow traffic within the building definitely affect the intake cows will achieve (Cook and Nordlund, 2004). Intake can vary widely between individuals in a herd with a lot of competition for feeding space. Especially the intake of heifers is easily restricted by competition with older cows. The provision of adequate feeding space reduces this kind of competition largely. The grouping of cows and social behavior also have their implications. A lot of attention should be paid to this point because during the transition period cows are transferred several times from one group to another. Each transfer or relocation implies another challenge for the cows as it brings them in contact with a new group and a new ration. All the energy that is spent in establishing a new social hierarchy is no longer available to produce or reproduce. At the same time, each change in the ration causes a serious drop in dry matter intake and should therefore also be avoided (Cook and Nordlund, 2004).

Although veterinary practitioners are currently not the only advisors on modern dairy herds, they have the advantage that they can use their "clinical eyes" to interpret what is happening in the herd (Zaaijer and Noordhuizen, 2003). Besides the use of herd production data which are usually readily available, the use of clinical scoring systems has been proven to provide the veterinarian with an extra tool to evaluate the health status of the animals in relation to their production level. Hence, these scoring systems should be used to evaluate the management system used on the herds at a regular time interval.

Furthermore, today's dairy cows may face a wide variety of environmental stressors. These may include overcrowding, infectious challenges, poor ventilation, poor footing or other forms of chronic or even acute pain, uncomfortable stables, rough handling, and frequent relocation in another group. Most of these stressors affect fertility and should therefore be avoided (Dobson and Smith, 2001). Although stress is difficult to define and to show to the herd manager, a lack in cow comfort compromising the cows' health and fertility should be noticed and discussed during the regular herd health visits. While top managers have it at their finger-tips and do not need a lot of explanation to adapt their herd to the needs of their modern top producers, others definitely need to be confronted with some eye-openers.

Conclusion

In view of the complex nature of fertility, it is not surprising to find that ideal fertility criteria are extremely difficult to achieve. When infections are involved in a subfertility problem, this can be due either to specific (e.g. BVDV) or non-specific genital infections. The former often strike a whole herd, causing abortions and repeat breeding. The latter are opportunists of unsanitary conditions during calving, dystocia and abnormal puerperium. They often take an insidious course.

It is generally agreed, however, that the main negative influence on the fertility of a dairy herd stems not as much from specific or non-specific infections, but rather from the effects of a host of other factors. These factors seldom exert their effects individually but rather interact together, making it difficult to analyze infertility in a given herd. For example, the advancement of animal husbandry practices has increased both herd size and production, but man hours per cow have dwindled. The direct result of this decrease is that less time remains for detecting heats, instituting hygienic measures and trimming claws. Thus the final fertility status of a dairy herd is the result of interactions of a whole range of factors from environmental conditions such as season, herd size and age composition, to pure managerial factors such as breeding policy, nutrition and estrus detection. Breeding efficiency depends almost totally on whether or not the farmer is able to skillfully cope with these factors in his herd. By way of conclusion, subfertility has been proven to be a multifactorial disease and the optimization of herd fertility often requires the optimization of several interfering managerial factors. There is almost never a single solution. Although poor fertility is becoming more and more common in our top dairy herds, there is a wide variation between herds and sometimes between years within the same herd. This latter fact illustrates that the dairy herd acts as a dynamic structure and may need specific adaptations, depending on the specific situations the herd actually has to face.

Fertility of a dairy herd is thus a relative phenomenon, expressing what the cows have been able to achieve in the face of a host of interacting factors. To avoid a deterioration of fertility below the accepted standards, the advice given to the farmer should enable him to optimally manage his herd under the given environmental and management conditions. Such advice can best be given by paying regular visits to the farmer (Herd Health and Fertility Control Program) so as to impress upon him the relevant factors of management. Hence, the follow-up of the reproductive performance of a dairy herd should be continuous and not only be restricted to the curative interventions when things are really going wrong.

The cornerstone to improving the reproductive performance of lactating dairy cattle also involves the understanding of the biochemical and physiological principles controlling reproductive and lactational processes. The challenge is to integrate this knowledge into nutritional management, production medicine and reproductive management procedures, taking into account the specific obstacles each individual herd has to face, for the purpose of optimizing the fertility of the herd (Thatcher *et al.*, 2006). In the absence of such a holistic approach, the response to traditional veterinary therapies and herd health programs may increasingly diminish.

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