

# Stress and Its Effects on Fertility of the Dairy Cow

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## ■ Take Home Messages

- It is important to identify the incidence of major stressors on each individual farm - these will vary from farm to farm.
- Some every-day events are stressful for cows.
- Lameness and bad calvings have significant effects on fertility.
- Mastitis is also painful and has a major economic impact.
- Try solving one problem at a time.
- Financial considerations will probably dictate your emphasis.

## ■ Introduction

Herds of wildebeest on the plains of Africa are normally capable of maintaining greater than 95% pregnancy rate to first service and thus a six-week calving period. By comparison, in the 21<sup>st</sup> century, can we claim to have successfully domesticated cattle for efficient milk production?

## ■ Do We Really Know How to Keep Cows?

Do we really know how to keep cows? Are we sure we appreciate all the consequences of those everyday management decisions that we make in the name of domestication of this species? What does it matter how we feed our cows?; what does it matter which bull has the best indices for ease of calving, udder conformation or foot angle?; ....what conditions are like under-foot in our

fields, walk-ways and buildings?; when and how we trim our cows' feet?; when and how we move cows between groups?

Bringing it to a personal level, do you know how many of your cows have a condition score of less than 4 (on a scale of 1-10) three weeks before the start of the breeding period? Do you know the exact proportion of your cows that had mastitis or milk fever? precisely how many were lame, and how lame they were? how many had to have assistance at calving last year? how many had a dirty uterus after calving? And what does it matter anyway, when we are sending off more milk to the dairy than ever before?

**Table 1. Average annual incidence (per 100 cows) of clinical conditions in dairy cattle in UK and consequent lost profit**

Problem	UK			Canada
	% Incidence	Cases per cow	£ per cow	\$ per cow
Retained membranes	4	1.0	298	685
Milk fever	8	1.0	220	505
Assistance at calving	9	1.0	5	12
Dirty uterus	15	1.4	166	380
Lameness	17	1.4	273	630
Mastitis	21	1.6	218	500
Estrus not observed	34	1.4	18	40

(data from Esslemont et al, 2000)

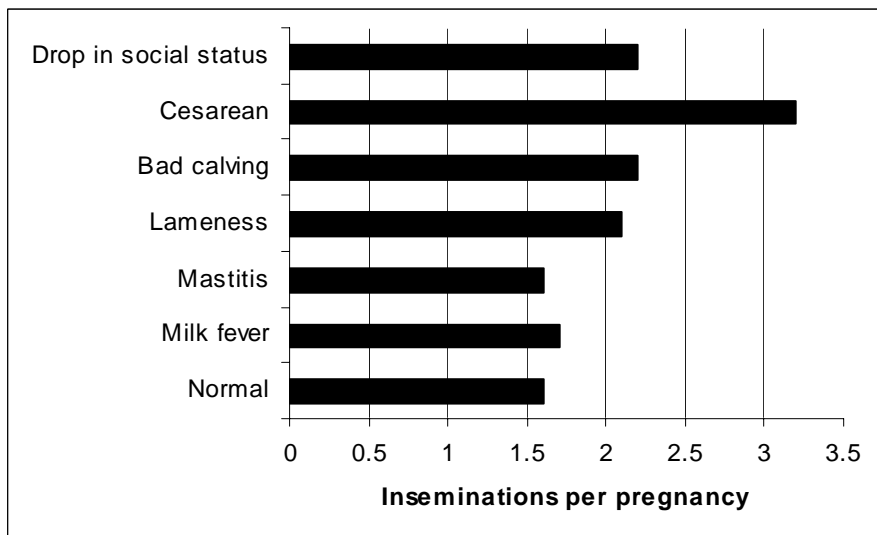
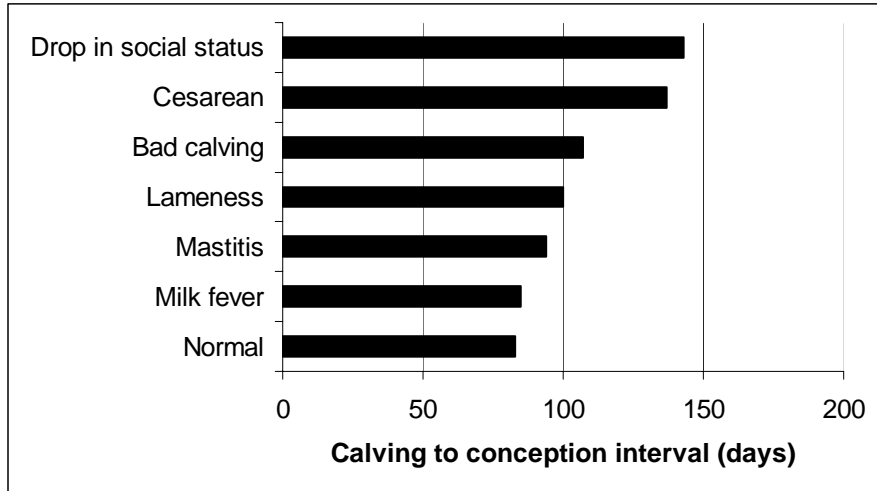
Several studies have attempted to answer these questions, and the results are alarming. Data are presented in Table 1 and to hit home, the economic consequences per case are also high-lighted – but remember these data ignore the impact on the cows themselves, i.e. the welfare of the animals. In the UK, owners are obliged to uphold the Five Freedoms of their animals. These are

- ▶ Freedom from hunger and thirst
- ▶ Freedom from discomfort
- ▶ Freedom from pain, injury and disease
- ▶ Freedom to display normal behavior
- ▶ Freedom from fear and distress

## ■ Clinical Events Affect Fertility

Each of the clinical conditions in Table 1 compromises the welfare of cows as well as having knock-on effects on fertility. The latter has been established by comparing fertility data of normal cows with those of herd-mates suffering from these distressing conditions. Examples of the results from these studies are

shown in Figure 1. Remember all the animals had been treated for these conditions, either by the farmer or by a veterinarian.



**Figure 1: Influence of treated clinical conditions on calving to conception and inseminations per pregnancy compared to normal herd-mates**

As might be expected, the severity of each condition also has an effect...

Considering milk fever, the more severe the case (and hence the worse the stress), the greater the effect on fertility. On average cows that succumb to milk fever take an extra 10 days to get pregnant; cows that totally collapse with milk fever (downer cows) take 15 days – if they live!

Both milk fever or a difficult calving are known to delay uterine involution. These effects, along with suppression of the immune system due to stress, will predispose cows to uterine infection (endometritis). We now have preliminary evidence that shows infections within the uterus have direct effects on ovarian follicular growth. Postpartum ovarian activity normally begins in the ovary on the opposite side to the previously pregnant horn. The presence of a purulent vaginal discharge decreases the number of animals resuming ovarian activity on that contra-lateral ovary and cows with purulent mucus take an extra 15 days to conceive (Sheldon et al, 2000).

Cows with a difficult/bad calving take an extra 8 days to resume ovarian activity, are more prone to subsequent abnormal cycles, and thus take 23 days longer to conceive than normal herd-mates. Our recent studies have also shown that cows with difficult calvings have ovarian follicles approximately 2.5 mm smaller at the start of the breeding period i.e., 35-50 days postpartum. If things get worse during the calving and a cesarean operation is required, the consequences for fertility are dire. Many farmers do not rebreed these animals (culling is an important component of fertility indices) but if the cows are rebred within 50 days after calving, an extra 40 days are required to achieve conception (Dobson et al, 2000).

During the nine weeks before diagnosis of lameness, pregnancy rates are low (31%). The severity of lameness can be scored to estimate the extent of stress (number of days lame x [severity score + structure score]; see Collick et al (1989) for details). Compared with normal herd-mates, cows with a high score take 100 days longer to become pregnant, have lower first insemination pregnancy rates (41% versus 56%), require 0.5 more inseminations per pregnancy, and are three times more likely to be culled (22% versus 7%).

Mastitis is also a painful event and subclinical mastitis is routinely detected in dairy cows by an increase in somatic cell counts (SCC). In the UK, a tank bulk milk count of >400,000 cells/ml for three consecutive months means that the farmer can not sell that milk. Even if only one of the five monthly recordings after calving exceeds this limit, 7 days are lost on the calving to pregnancy interval; if all five recordings are too high, 12.5 days are lost. If Gram negative infections are diagnosed, the post-partum resumption of ovarian activity is delayed by an average of 17 days.

## ■ Even Simple Management Decisions Affect Fertility

It is not only overt clinical cases that are associated with reduced reproductive efficiency. Rearrangement of animal groups can cause trouble, especially in restricted environments such as (winter) housing. If one dominant animal is placed within a new group of other animals, the individual somatic cell count of several of the animals (as well as the bulk milk count) will be elevated. Furthermore, changes (for whatever reason) in the hierarchy of an otherwise stable group can have profound effects on reproductive indices. We have monitored three groups of approximately 50 cows on three different commercial dairy farms during the breeding period. On the initial day of observation, submissive and dominant behavior was observed and the cows were placed in a 'pecking-order'. The degree of lameness was also scored on a 0 - 5 point scale, with 5.0 representing a very lame animal. One month later, the behavioral observations were repeated. A total of 45 animals were noted to have dropped 5 or more places down the order, and a further 45 animals had risen in hierarchy position. Comparison of the production indices of these groups of animals revealed interesting differences (Table 2). Those animals that did **not** change position maintained adequate fertility, even if they were at the bottom of the pile. However, those that declined in social status had decreased reproduction indices and milk yield, whereas SCCs and lameness scores increased. In a study like this it is not possible to be certain what was cause, and what was effect. For example, were these indices altered because of the increased lameness, or did animals succumb to lameness because they had become more stressed? More work is required in this area.

**Table 2: Summary of fertility and milk production data for 45 pairs of cows that either increased or decreased in social status during the breeding period in three commercial dairy farms.**

	Change in social status	
	Increase	Decrease
<b>Calving to conception (days)</b>	97	143
<b>Inseminations per conception</b>	1.6	2.2
<b>Milk yield (kg/day)</b>	+0.58	-1.03
<b>Somatic cell count ('000/ml)</b>	-18	+371
<b>Difference in lameness score</b>	0.21	+0.54

(reproduced with permission from Dobson and Smith, 2000).

Regretfully, many of these situations are all too common in lots of dairy herds throughout the world. At least we are now beginning to realize how inefficient we have been at domestication, where the mistakes have been made, but are we developing adequate appropriate strategies to overcome these failures?

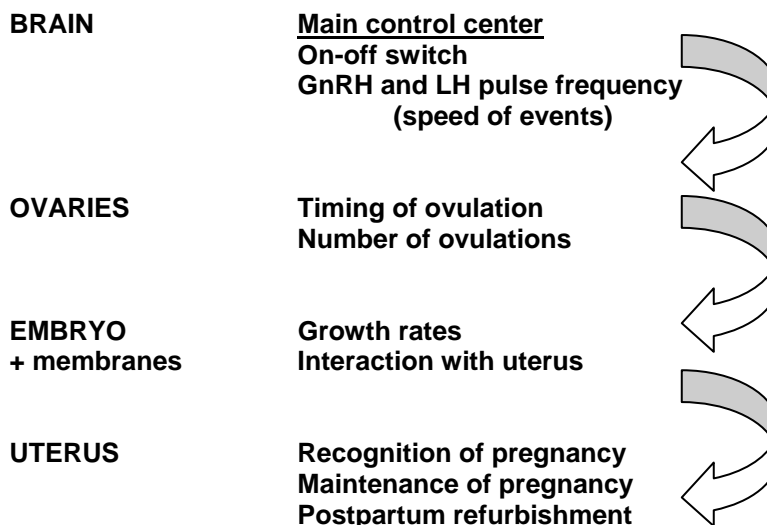
Initially it is necessary to identify where/when the failures are occurring but .....it is not enough to recognize problems without thinking about solutions?

## ■ How Do You Measure Stress?

We are often asked 'what can be measured to show that animals are suffering from stress?' Many will suggest that measurement of cortisol in blood or milk will prove that animals are 'stressed'. However, secretion of adequate amounts of cortisol is essential for survival. When challenged by any situation that deviates from normal, an animal will release cortisol and adrenaline from the adrenal glands. This is part of the 'fight or flight' scenario during which cortisol and adrenaline will restrict blood supply to some non-essential organs but maintain supply to others. It is important that animals can react to their environment in such a way that they can adopt effective strategies, such as running away! But excessive cortisol will suppress the immune system and interfere with efficient working of many other normal body functions – including reproduction. Thus, cows can react to the appearance of strangers by an increase in cortisol and walk away but without long-term deleterious consequences. However, if the stressor is so bad that the animal fails to cope, eventually even such an important function as passing genes on to the next generation (reproduction) will suffer. So, if we can associate stressful/painful events with a reduction in reproductive efficiency, surely this is a good measure of stress? Reproduction is not the only worthwhile index to measure. Any other essential physiological function could be used, e.g., efficiency of food conversion, respiratory quotients, or neural transmission. However, as a reproductive physiologist, it is of interest to examine exactly how stressors can interact with the reproductive system.

## ■ The Physiology of Stress-Reproduction Interactions

Briefly, there are four principle sites at which activation of the stress response can influence reproduction (Figure 2). The **brain** is the main control center; it has the major power to maintain the reproductive system. Either to have it switched off completely or, if allowed to function, to determine the speed at which things happen, for example, the frequency of GnRH and thus LH pulses emerging from the brain to will dictate the rate of ovarian follicular growth. There is control at the **ovaries** over the timing of ovulation as well as the final number of follicles that ovulate. The **conceptus** (embryo + plus membranes) must grow at optimum rates and interact with the uterine lining, and finally the **uterus** plays a part in the maternal recognition of pregnancy, the maintenance of the embryo and fetus as well as during uterine refurbishment in the postpartum period.



**Figure 2: Possible sites for ‘stress’ to affect reproductive efficiency**

There is evidence for the suppression of GnRH and LH pulse frequency during exposure to a stressor, and as already stated, we know that follicles do not grow as big when animals are stressed. Furthermore, we have shown that events around estrus (for example, the preovulatory LH surge) are delayed with consequent delays in ovulation. All this leads to reduced pregnancy rates. To date, there have been no cattle studies to investigate any possible deleterious effects of stressors on conceptus growth, maintenance of pregnancy or postpartum uterine involution.

### ■ Strategies to Avoid Stress

So what about the solutions to these problems of stress-induced subfertility? We ignore the problem at our peril. Culling the offenders is not an economic option, as too many animals would need to be removed from a lot of herds. Furthermore in Europe, it is not possible to resort to the pharmaceutical industry as our savior. It is not deemed acceptable to treat large number of animals with hormones to overcome the gradual decline in fertility due to poor stockmanship.

The main strategy must be based on prevention. Improved attention to husbandry matters will reduce the magnitude of the stressors high-lighted above. This in turn will improve animal welfare, increase fertility indices and thus boost profitability of milk production. So having identified some of the key

stressors, what are the major management decisions that require thinking about?

Mastitis affects fertility as well as many other economic outcomes. Attention to milking equipment and routines will pay dividends. Milk fever also reduces subsequent fertility both by activating a stress response as well as by interfering with uterine tone, impairing uterine involution and thus inviting opportunist infection. Attention to dry period nutrition, especially cation balance, appears to be an effective way of decreasing the incidence of this periparturient condition. Nutrition in early lactation clearly has a great role to play in fertility in the postpartum period, and previous authors have already discussed its effects. We are also just beginning to realize that adequate diets in very early pregnancy have long-term effects on the fertility of off-spring when they become adult themselves.

One of the primary strategies to prevent unnecessary stress lies in the choice of bull – whether for use naturally or by AI. Hoof/leg and udder conformation as well as SCCs are heritable characteristics and can thus influence outcomes later in the productive life of female offspring. Choice of an easy calving bull would relieve a lot of pressure on the dam – especially if she is a first-time calver. Thus many problems can be avoided by judicious choice of genetic lines. Scandinavian sires are assessed for daughter health and fertility. The route to this improvement in the female is breeding for a cow's ability to manage its condition adequately while producing large amounts of milk.

Further problems around calving can be circumvented by having the expected calving date in the records and close attention to diet in the dry period. There is a nutrient partition ratio in favor of the fetus in the later stages of pregnancy and thus feeding of the dam during the last month of the dry period is important for this reason, as well as for calcium metabolism as discussed earlier. Manual interference during calving predisposes cows to slow uterine involution and uterine bacterial contamination. Provision of clean calving locations (preferably outside – sunlight kills bugs!) and minimal interference are recommended.

Prevention of lameness will have a big impact on stress-induced subfertility. As already mentioned, this begins with choice of bull and is heavily influenced by feeding especially in early lactation of dairy cows. Appropriate, timely foot-trimming and foot-bathing will pay dividends, as will attention to provision of non-abrasive walk-ways that avoid trauma to the hoof.

Other potential husbandry aspects include maintenance of a heifer group at least for the first 4 months of lactation if not all the first lactation. This will permit these lighter weight animals to enter fair competition at feed troughs, as well as pre-empting other hierarchical bottlenecks. Maintenance of stable social groups should reduce subfertility due to loss of dominance.



## ■ How Do You Measure Reproductive Efficiency?

A blanket approach to prevent the impact of all these stressors at one time will not be cost-effective. Accurate conscientious event-recording is the key to a successful stress-reduction policy to keep losses to a minimum. It is important to know the key basic reproductive parameters on each farm, for example,

- How many cows show estrus within 25 days after calving, and within 25 days after the earliest breeding date?
- What percentages are inseminated after calving?
- What is the distribution of inter-estrus intervals (see Table 3)?
- How many cows get pregnant to the first insemination?
- What is the interval to conception from calving, and from the earliest breeding date?
- How many inseminations are required per pregnancy?
- How many cows are culled for failure to conceive? Is there an equal monthly distribution?
- Having done a CuSum (cumulative summation) of positive/negative pregnancy diagnosis for each chronological insemination, are there specific periods during which inseminations were unsuccessful?

**Table 3: Distribution of inter-estrus intervals as indicators of estrus detection efficiency.**

Inter-estrus intervals (days)	Typical spread (%)	Target (%)	Poor detection	Wrong detection
1 – 17	5		5	>15
18 – 24 (normal)	50+	70	<45	40 – 50
25 – 35	5 – 10		5 – 10	>15
36 – 48 (missed heat)	15	10	15 - 30	10
>48	20		>15	>15
>78		1 - 2	>15	>15

Thus it may be possible to identify the main cause(s) of subfertility, for example,

- Is heat detection as good as it could be? i.e., are there greater than 15% returns to heat between 1- 17 days and 25 and 35 days after insemination?
- Or are there a large number of heats between days 25 and 48 (sometimes indicative of early embryonic death)?
- Is there a delay in cows showing heat after calving?
- Are more than 1.8 inseminations required per pregnancy?
- Are there specific periods in the year when the wheels fall off?
- What other events occur at these times on this farm? Any co-incidence with housing, turn-out, silage making, holidays, weekends?

In addition, it will be necessary to know the annual incidence of the main stressors on each farm, for example,

- How many cases of milk fever are there?
- How many calvings are assisted; and the scale of assistance?
- How many cases of dirty discharges are there?
- How many lame cows are there?; how lame are they?; and how long are they allowed to be lame?
- How many cases of mastitis are there?
- How many cows have SCCs >400,000 in the first 5 months after calving?
- How many cows are culled with the main reason given as mastitis or lameness?

## ■ Strategies to Reduce the Financial Impact of Stress

To prepare an appropriate action plan for a particular farm it will be necessary to check the records and prioritize each of the above stress parameters. This can be achieved with Dairycomp 305, Dairy Champ or Interherd). Comparison of results from the UK top 25% reproductively efficient farms (Table 4) should make it possible to identify which stressor requires elimination most urgently. Putting financial figures into the equation will help concentrate resources in appropriate economic areas. The total cost of each 'disease' includes treatment costs, loss of revenue from milk and cost of appropriate culling and replacement. This is the basis for direct costs in the Healex score. The examples in Figure 3 relate to several farms over a prolonged period. Clearly, cows treated for estrus-not-observed (ONO) has a high incidence mastitis has the greatest overall impact. If all the costs of all the diseases are combined (Figure 4), it is obvious that 1993 was a bad year but possibly higher culling rates of older cows in the UK (BSE) plus greater subsequent attention to mastitis almost halved its impact by 1997.

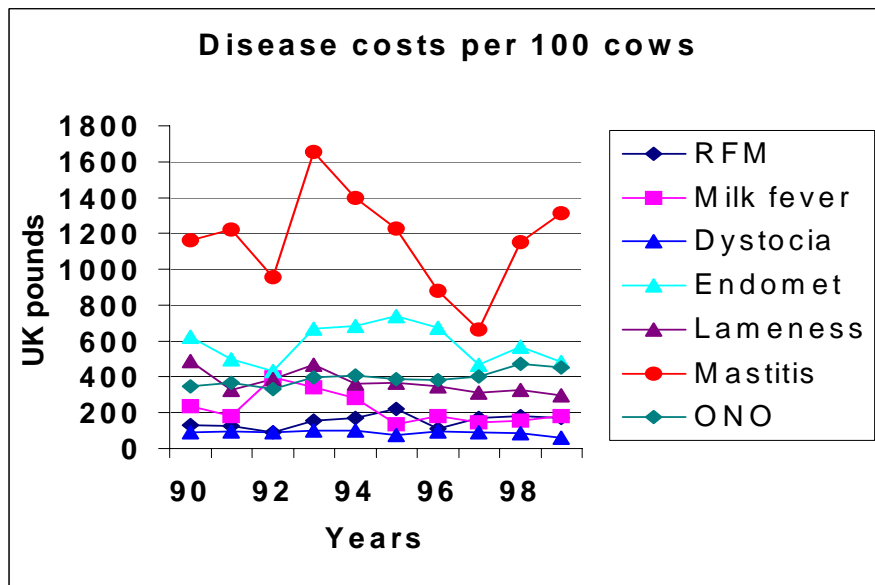
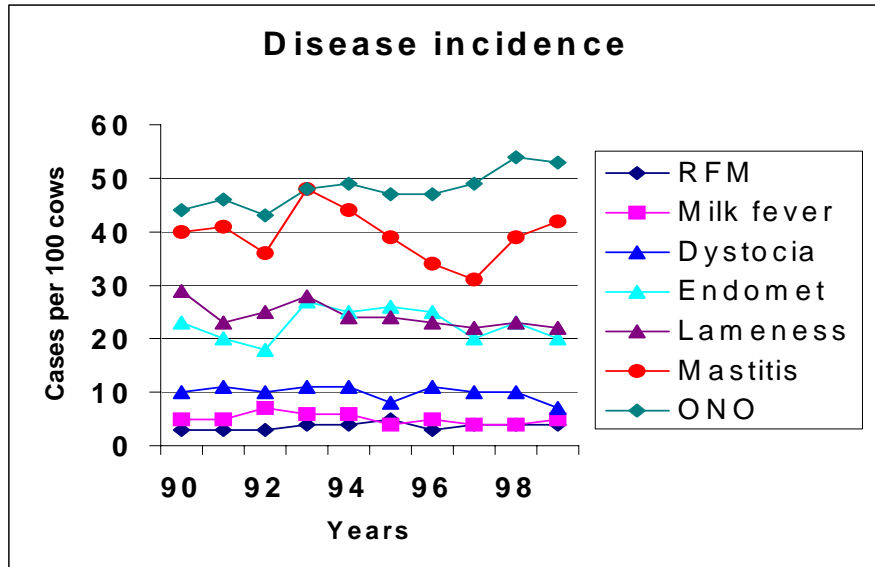


Figure 3: Average disease incidence and costs per 100 cows for the same 52 UK farms (>8000 cows) over a ten year period (reproduced with permission from Esslemont and Kossaibati, 2002). Yield increased ~100 liters/cow/year over the same period.

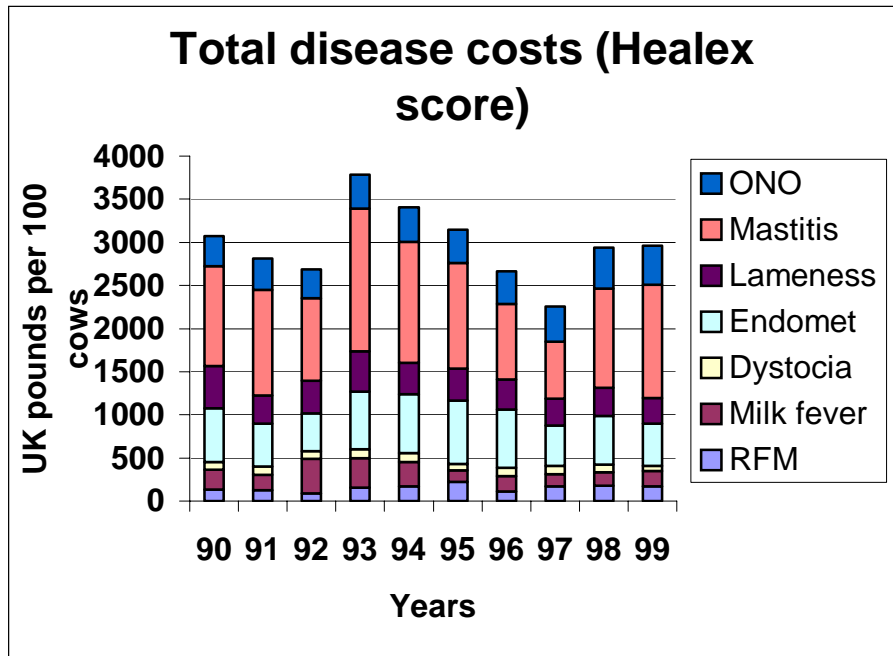


Figure 4: Average total disease costs per 100 cows for 52 UK farms over a ten year period (reproduced with permission from Esslemont and Kossaibati, 2002).

**Table 4: Health management assessment: comparison of quarter results from 52 UK herds from 1995-2000**

Problem	Quarter of each herd			
	Top "Target"	"Tolerable"	"Problem"	Bottom "Disaster"
Retained membranes - cases per 100 cows	<2	3 - 4	5 - 6	>6
Milk fever - cases per 100 cows	<3	3 - 6	7 - 10	>10
Assistance at calving - cases per 100 cows	<2	2 - 7	8 - 15	>15
Dirty uterus - % of herd affected	<6	7 - 13	14 - 21	>21
- cases per 100 cows	<7	8 - 19	20 - 31	>31
Lameness - % of herd affected	<9	9 - 13	14 - 20	>20
- cases per 100 cows	<12	9 - 20	21 - 30	>32
Mastitis - % of herd affected	<17	17 - 20	21 - 29	>29
- cases per 100 cows	<22	23 - 30	31 - 55	>56
Estrus not observed - % of herd affected	<22	23 - 34	35 - 42	>42
- cases per 100 cows	<28	29 - 47	48 - 63	>63
<b>Healex score £ per 100 cows</b>	<b>&lt;309</b>	<b>1190</b>	<b>3631</b>	<b>5915</b>
<b>Healex score CA \$ per 100 cows</b>	<b>&lt;710</b>	<b>2740</b>	<b>8350</b>	<b>13,604</b>

(modified from Esslemont and Kossaibati, 2002)

In this way, a tailor-made approach can be prepared for individual farms and realistic targets set for the forth-coming year. Trying to solve all problems on one farm all at once can be demoralizing if there is a lack of perceptible progress. Whereas making a positive impact on one targeted problem at a time will have psychologically beneficial effects.

## ■ Further Reading

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