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Understanding Bovine Mastitis as a Dynamic Enzootic

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Controlling the Fluxes of a Disease Inherent in High Level Dairy Farming through Epidemiology

«Nature hates normality»
Chris Carter

1. Introduction

Health disorders in bovine herds are, in essence, multifactorial. They are based on the equilibrium among various factors. The major difficulty in managing endemias in livestock production emerges from two elements: the extreme variability of practices among farms and over time on one hand and on the other hand, the crossed impact of various factors producing the same result.

A simple example will illustrate the two problems: Mastitis has epidemiological components that govern their own response to means of prevention. Because no two dairy farms ever have fifty per cent of their livestock production practices in common, the establishment of the usual means of prevention will never have the same dosable impact in each of the two farms (Bradley et al. 2007; Théron et al. 2009). Further, in view of the variability of certain practices or adjustments over time, a situation can vary while all other factors remain constant, due to a neglected invisible factor, thus diminishing the strength of the prevention argument. Each of us has known situations in which post-dipping did not generate the anticipated effects, and situations in which, after a transitory improvement linked to milking practices, the situation degrades again for a cause associated with the milking machine or feeding. The conclusion of this introduction is both simple and complex: the integrated control of mastitis is based on long-term monitoring. This monitoring is justified by the economic and societal impact of this disease. Good monitoring implies the definition of key measurable control points. The aim of this article will be to define the indicators and epidemiological objectives that enable the level of mammary health and its evolution to be defined over time.

2. Performance objectives

The clinical examination of a herd is different from a classic consultation. It entails the epidemiological analysis of the problem. An analysis is thus performed of the herd functions, that is, of the functions common to all the animals. Thus, the cleanliness rating of the animals will be the average of the individual cleanliness scores. This analysis will enable the identification of a nuance between two herds between two points in time as regards the evolution of a herd. These clinical scores, such as body condition, lesions on the teats, the digestibility of fibres, and the frequency of mastitis are our clinical signs on the population scale. They point us toward an affected farm system that should be investigated, including complementary examinations, to determine the root cause of the problem. Three characteristics of mastitis must also be understood: clinical severity, chronicity or not, recovery or not (Table I).

	Manifestation			Development		
	Month -2	Month -1	Mastitis	Month +1	Month +2	End result
Acute	-	-	+	+/-	-	*Recovery*
	-	-	+	+	+	*Persistence*
Chronic	+/-	+	+	+/-	-	*Recovery*
	+	+	+	+	+	*Persistence*

Table I- Type of physiopathological behaviour over time of mammary infections compared to a CCSI threshold

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Mastitis has two typical epidemiological origins: the environment and already infected mammary glands (Fig. 1); the germs associated with these two models are different. The complexity lies in the fact that most of the germs can take the form of the two models, more or less, according to their affinity. Thus, *Streptococcus uberis* is a pathogen that comes from the environment, but that can easily be transmitted from cow to cow during milking. By contrast, *Streptococcus agalactiae* originates almost exclusively in infected glands. The definition of the model will undoubtedly have an impact on the understanding of the problem and on the means of treatment and prevention.

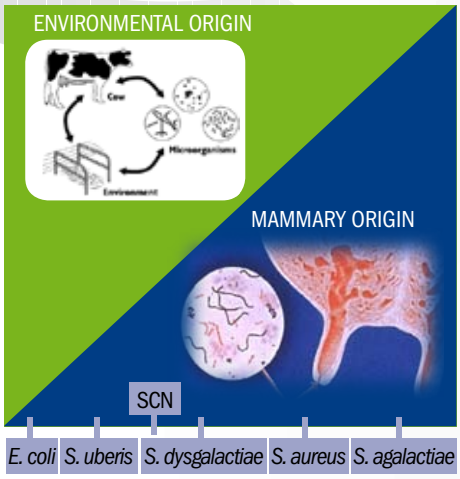

Figure 1. Epidemiological behaviour of the principal mastitis-causing germs

In order to establish the indicators of mammary health, it is advisable to take an inventory of the available data:

1. Clinical cases of mastitis, their treatment and severity
2. Individual somatic cell counts (SCC, milk monitoring) associated with the level and stage of production
3. Tank milk composition
4. Available supplementary analyses (conductivity, daily SCC, California mastitis test, colorimetry, etc.)

While the second and third types of data are often accessible, the first is sometimes difficult to obtain and the availability of the last is variable. With the help of the tank milk composition, frequently recorded in our countries, one can already identify one part of the inflammatory, hygienic and nutritional factors (Rysanek, 2005). This measurement, however, always carries a bias that is linked to the animals present in the tank. The SCCs enable a more precise analysis to be made of the epidemiology and nutrition, but they are paradoxically less frequent and therefore sometimes obsolete as regards the appearance of the problem (fig. 2). However, the meticulous study of the SCCs can reveal fine variations that are harbingers of modification.

Various authors have issued their rulings on the objectives to define and the performance indicators in bovine mammary health. Thus, the rate of clinical mastitis was defined and assigned an alert threshold at 30% of clinical cases per year (Radostits et al. 1998, Seegers et al. 2011). This is defined by the total number of clinical mastitis cases divided by the number of lactations during a year. Green et al. established the systematic use of indicators derived from SCCs such as the rate of recovery at dry off, the contamination rate, etc. (Bradley et al., 2007, Green et al., 2006, Green, 2007). Finally, some teams propose the combined use of clinical mastitis cases and SCCs in order to understand the evolution of these parameters and the overall economic impact of this pathology (Théron et al., 2011; Reding et al. 2011).

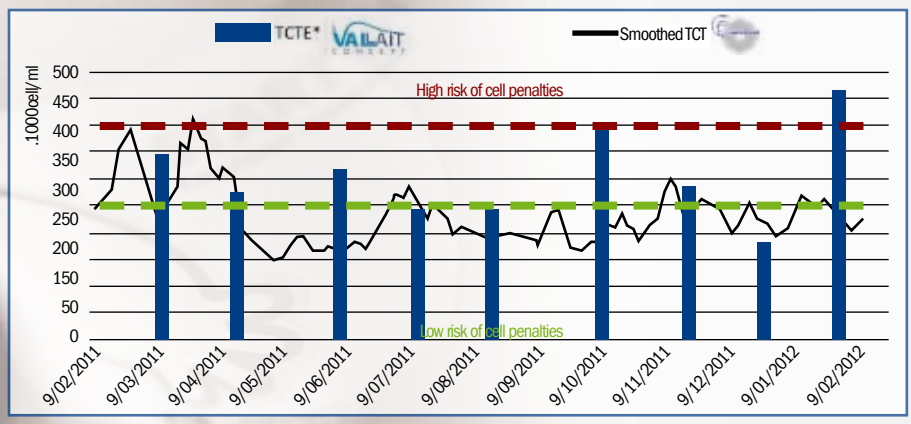

Figure 2. Paralleling the tank cell concentration (smoothed TCT in black) and the average weighted by the production of individual cell concentrations in milk monitoring (TCTE, herd cells in blue). The specific modifications undergone by the herd are sometimes not visible during milk monitoring (taken from the LAECEA project set up by the Université de Liège and the Association Wallonne de l'Élevage–the Walloon Farming Association).

3. Main epidemiological indicators of mammary health

It should be noted that the analyses of the epidemiological indicators form part of the history of the herd and they should not become detached from the clinical findings. Happily veterinary medicine by computer has not yet arrived! These analyses form the upstream side of the analytical work, monitoring provides the downstream side, but both must be integrated with the clinical picture based on the study of the livestock themselves (Fig. 3).

In order to make our aim clearer, we will present the use of tank cell counts and the safety threshold of 250,000 cells / ml, as well as the indicators connected with the study of the individual SCC. For this purpose, the usual development of a mastitis problem must be understood according to its duration and evolution (Table II). This approach makes it possible to adapt our view of a clinical case and of its curability, inasmuch as old infections are unlikely to be cured during lactation. In addition, it enables the effectiveness of treatments to be known.

A cow under 100 can be considered healthy
A cow over 300 is definitely considered infected

Healthy old cow late lactation may be over 100 and subclinical heifer may be less than 300. The virtual majority of authors agree on the limit of 200,000 cells / ml as the reference threshold for separating the healthy animals from the sick ones with the best sensitivity / specificity. Some recent publications put forward the fact that primiparous cows present very low SCCs, and that a theoretical threshold of 150,000 or 100,000 cells / ml would be more appropriate for the dynamic study of cell concentrations.

In any case, in a recent discussion group at the European Buiatric Forum conference, a group of experts in mammary health stated that the threshold chosen was of little importance in the end, provided that the same threshold is maintained from one herd to the other and that the cell count variations around the threshold are interpreted correctly.

By using these primary indicators, we can define secondary indicators linked to the cure or chronicity of the infections (Table III). According to the available data we may simplify the analysis by taking into account only the cases of subclinical mastitis or only the clinical cases.

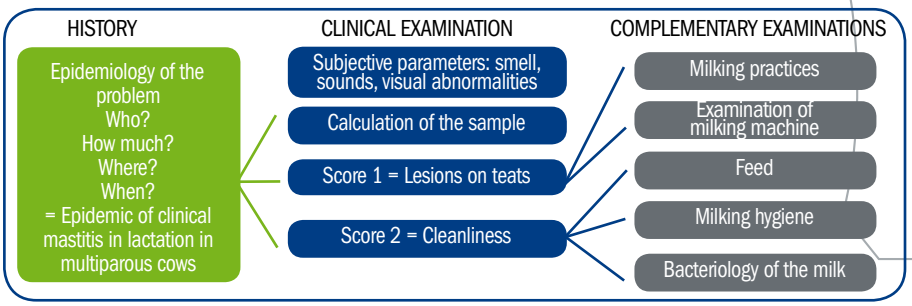

Figure 3. Simplified framework presentation of an approach to a herd problem (taken from Durel et al. 2012)

INDICATOR	CALCULATION
Clinical animal	MC = Animal that has presented a clinical mastitis
Subclinical animal	MSC = Animal having an increase of CCSIs without clinical signs
Healthy animal	A = øMC + øMSC
Infected animal (basic)	IA = MC + MSC (CCSI > 200,000 cells/ml)
Infected animal (expert)	AI = MC + $MSCI_{primiparous}$ > 150,000 cells/ml + $CCSI_{primiparous}$ > 250,000 cells/ml
TP: Monthly mastitis prevalence rate	$TP = \frac{\Sigma \text{ IA of the month}}{\Sigma \text{ (A + IA) of the month}} \times 100$
TI: Monthly mastitis incidence rate	$TI = \frac{\Sigma \text{ AI of the month not infected the previous month}}{\Sigma \text{ (A + IA) of the month}} \times 100$
TC: Monthly rate of persistent infections (chronicity)	$TC = \frac{\Sigma \text{ IA of the month already IA in the previous month}}{\Sigma \text{ (A + IA) of the month}} \times 100$

Table II - Clinical and subclinical mammary health indicators (the classic evaluations will be placed under the "basic" heading; the expert appraisals will be more precise, but require more analysis time)

INDICATOR	CALCULATION
TGEL: Monthly cure rate during lactation	$TGEL = \frac{\Sigma \text{ A of the month and IA treated in the previous month}}{\Sigma \text{ IA treated in the previous month}} \times 100$
TGHL: Monthly cure rate at dry off	$TGHL = \frac{\Sigma \text{ A calved present and IA treated at dry-off}}{\Sigma \text{ IA treated at dry-off present}} \times 100$
TCGT: Overall cure rate	$TGT = \frac{\Sigma \text{ A of the month and IA in the previous month}}{\Sigma \text{ (A + IA) of the month}} \times 100$
TR: Relapse rate among the MCs (animals that have presented a clinical mastitis)	$TR = \frac{\Sigma \text{ MC and MC at less than 21 days}}{\Sigma \text{ MC}} \times 100$

Table III - Indicators derived from two successive analyses. Thus TGHL is calculated by taking the healthy and infected calved animals at dry off and dividing by the number of animals present that are infected at dry off.

4. Practical use of the epidemiology of mastitis

Obviously the analysis of these data is complex, and the ideal approach is to automate part of the calculations by using systems dedicated to dairy farming or adapted veterinary software applications. These data can be used in various ways; the first is statistical, a "photograph" of the herd in a given month that will enable the epidemiological constraints imposed on the herd to be defined.

Example: "What is the most affected epidemiological indicator in my herd?" or "Which is the key point of time of the infections affecting my herd?"

In the current situation of this herd, an excellent cure can be observed at dry off (81%) as well as a high level of healthy cows (71%) with low transmission (9%). This suggests an only slightly contagious epidemiological model. On the other hand, at calving, 14% of the healthy animals become infected. This suggests a reduction of the effectiveness of the means of prevention applied around calving time with the usual multifactorial succession associated with post-partum: nutrition, hygiene, transition, etc. Because one of the key points of mastitis management is at or near calving, an environmental origin of the contaminations that arise can be suggested. I will confirm this epidemio-clinical suspicion through a bacteriological analysis.

The other use of epidemiological indicators involves monitoring them over time (Figures 5, 6 and 7).

Example: "How is my mammary health situation evolving?" or "I've put my new product in place; what impact has it had?"

In our example, we can identify several problems: the rate of cure at dry off is quite good (>70%), the rate of contamination in lactation has risen (to around 17%), the rate of cure has varied greatly over the past three months (31%). The logical result is the increase in the prevalence of animals with >200.000 cells / ml (30 to 35%). Apart from that, instantaneous analysis shows us a level of post-partum contamination of 18% among animals that were healthy at dry off.

We can deduce that the herd is subject to a mixed model of contamination (environmental and contagious). This may mean a germ with variable behaviour or several different germs. Some of the main problems are the high recovery and contamination rates, which mean quite a high dynamics of pathogen circulation. There is, therefore, proliferation of the agent in the surrounding environment or contamination during milking by contaminating actions.

In the case of our example, bacteriology enables us to identify a coagulase-negative staphylococcus in five animals with subclinical mastitis. This confirms our suspicion of a mixed model, since these germs have a mixed origin. In addition, the absence of an appropriate calving shed could prompt us to identify the cause of the post-partum contaminations. In the milking room, we could observe deficiencies in the hygiene procedures before milking and the absence of post-dipping. Finally, from the bulk tank milk we can see significant variations in urea and butterfat content, suggesting, at best, less than consistent feeding practices.

5. Conclusions

Mastitis is a polymorphous disease that is difficult to control on a permanent basis, and very costly. Maintaining its prevalence at acceptable levels for a reasonable investment can prove a good on-going cost-benefit strategy. In addition, minor daily actions, such as a change of movements, personnel, equipment, etc. can have a significant effect on mammary health. Depending on the mode of analysis, it is possible to predict recoveries or, inversely, a worsening of the problems according to the epidemiological orientation with respect to cures and contaminations.

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In the light of the development of the typology of European dairy farms, this type of approach enables the examination of a herd to be standardised. For the future, it could also be a good set of indicators for the controlled use of antibiotics. Indeed, if 78% of the animals are healthy at dry off, the dairy farmer could opt for a selective dry off. Further, if treatments during lactation do not prove very effective, the farmer could decide to omit them and apply treatment at dry off. Such an approach is also a tool suited to the study of the impact of a change (motivation, equipment, vaccination strategy, hygiene, etc.).

In conclusion, the epidemiology of mastitis and the monitoring of health performance indicators are quite powerful tools for identifying problems, understanding the exposure pathways and controlling the pathogens involved. But they are not sufficient to guarantee a solution; the farm and its specific constraints must be known.

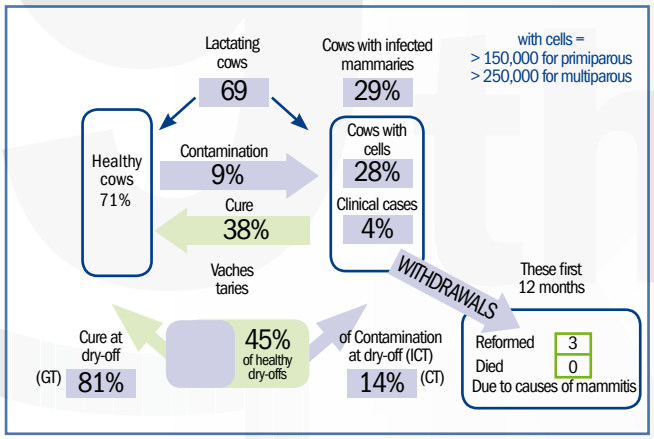

Figure 4. Epidemiological indicators and instantaneous infection dynamics (taken from LAECEA ULG-AWE Project)

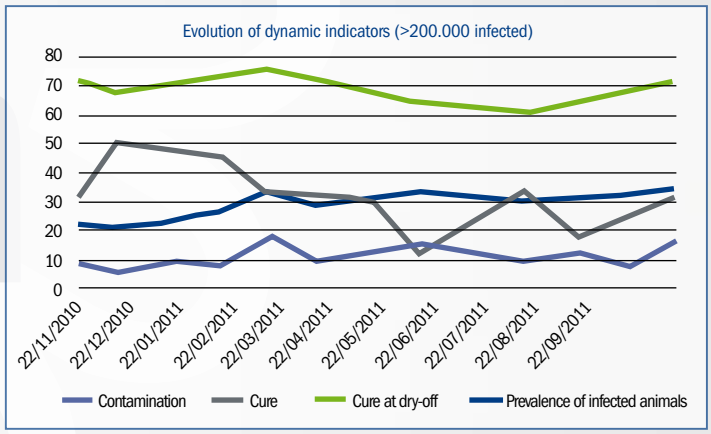

Figure 5. Time-dependent epidemiology to analyse the variations in the indicators

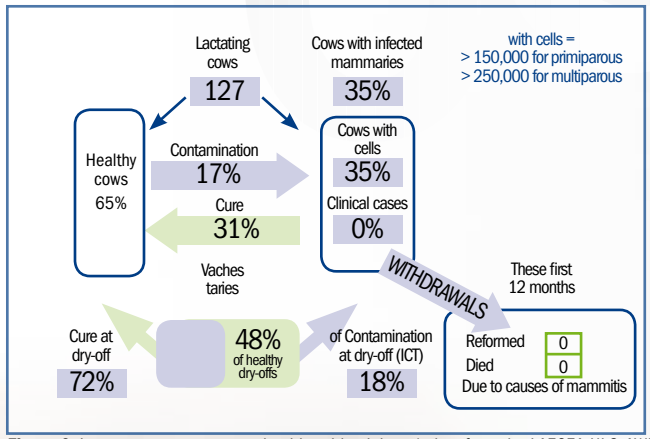

Figure 6. Instantaneous mammary health epidemiology (taken from the LAECEA ULG-AWE Project)

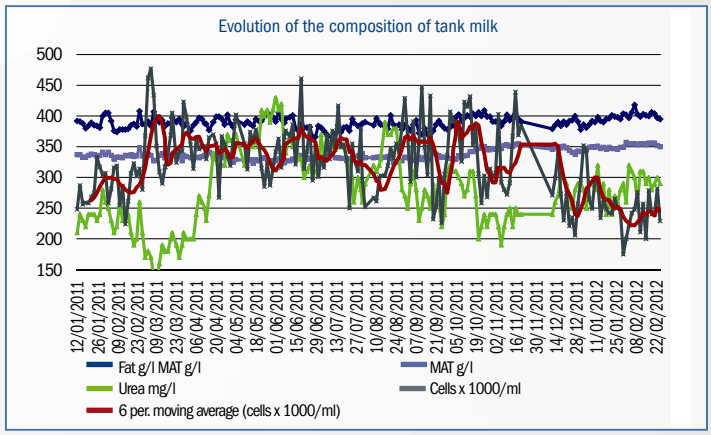

Figure 7. Comparative evolution of tank milk (the black line indicates the moving average of six consecutive results over a continuous period)

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