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ECONOMIC EFFECT OF SUBCLINICAL MASTITIS CONTROL IN DAIRY CATTLE : OBSERVATIONAL STUDY IN FRENCH DAIRY HERDS

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Les mammites subcliniques représentent l'une des entités pathologiques les plus fréquentes et les plus coûteuses en élevage laitier. La relation déjà établie entre le lait produit et le taux des cellules somatiques (en millier/ml de lait) permet d'estimer les pertes de production dues aux mammites subcliniques.
Un échantillon tiré au sort de 171 élevages laitiers en Bourgogne (France), a été suivi entre juin 1992 et juillet 1993. Les données récoltées concernaient 9075 vaches (comprenant le taux cellulaire dans le lait lors de différents contrôles, le stade de lactation, l'âge...), D'autres part, les pratiques d'élevage ont été recueillies à l'aide d'un questionnaire. Dans une première étape, le modèle de Bartlett a été utilisé afin d'estimer la relation entre le taux cellulaire et la production laitière dans le but de calculer la production théorique puis la perte par vache et par an. Le second volet de l'analyse avait pour but d'estimer les pertes en production liées aux différents facteurs.
La moyenne des pertes était voisine de 135.32 kg par vache et par lactation. Les primipares étaient plus touchées que les multipares. Les variables trouvées significativement liées à l'augmentation du taux cellulaire et donc à la perte en lait étaient les conditions d'hygiène et de propreté, la fréquence de paillage, le contrôle annuel et régulier de la machine à traire, et l'utilisation d'ammonium quaternaire pour la désinfection.

INTRODUCTION :

Mastitis is the most common disease in dairy cattle and the most costly (Miller et al., 1990 ; Blosser et al., 1979). The reported costs per cow vary considerably between studies (Jasper et al., 1982 ; Blosser et al., 1979). These costs are due to : Decreased milk yield, discarded milk, increased need for replacement cows, decreased sale value, drugs and veterinary services. The somatic cell count (SCC) has been used as an indicator of udder health in dairy herds as an easy to use, inexpensive and accurate. In fact, mastitis control programs from several countries use the SCC to monitor the animal health status and the progress achieved by the programs. SCC also used as a milk quality indicator and the basis for payment to producers.
Previous studies (Bartlett et al., 1990 ; Raubertas and Shook., 1982) have described the relationship between test-day SCC and milk yield, and reported a negative linear relation between units of lnSCC and milk production. Many studies have shown that practices aimed at decreasing mastitis prevalence such as : teat dipping and non lactating cow therapy result in decreases in quarter infection and increases in milk production. Other practices reported to decrease mastitis prevalence include good milking hygiene, milking machine maintenance, and regular veterinary visits (Blowey et al., 1992). However, studies which simultaneously assess the marginal effects of various management factors used to prevent mastitis in dairy production systems are limited. Evaluating economic benefit of management practices involves identifying practices that represent milking management, establishing a reliable system for assessing milking management practices, and identifying management practices that are predictive indicators of udder health (Goodger et al., 1993). The first objective of this study was, to evaluate the relationship between milk production and SCC using a statistical model developed by Bartlett et al., 1990, and Lightner et al., 1988, with data collected from French dairies. The second objective was, to quantify the association between these losses and certain mastitis control management strategies.

MATERIALS AND METHODS :

One hundred and seventy-one dairies were randomly selected from a group of 800 dairy herds in the Burgundy region and were followed during the period from June 1992 and July 1993. The management practices were recorded by mean of questionnaire including :General management, housing conditions, cleaning procedures, milking procedures and milking machine factors. All animals were from Prim'Holstein breed.
During the survey, the test day observations were obtained every 40 days, however, because a summer holiday in August and dry period, a minimum of 7 controls by animal was required. 67,170 test day observations for milk yield (in kg), stage of lactation, date of calving and somatic cell count from 9075 cows were recorded. SCC was determined using the Fossomatic method.
Two parts of analysis were developed, the first, was production loss assessment : The relationship between SCC and test day milk yield was studied using the model developed by Bartlett. Actual test day milk was used as the dependent variable. The model is the following :

$$Y_{ijklm} = \mu + H_i + C_{ij} + St_k + Mc_l + Ml_m + \beta_1(LnSCC) + \beta_2(LnSCC)^2 + \beta_3(LnSCC)^3 + \varepsilon_{ijklm}$$

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Where : [Y_{ijklm}: test day milk yield (67170 values). μ: intercept. H_i: effect of herd i (171 classes). C_{ij}: effect of cow j within herd i (9075 classes). St_k: effect of stage k of lactation. Mc_l:effect of month l of calving. Ml_m: effect of number of lactation m (2 classes primiparous and multiparous). lnSCC: natural logarithm of (SCC+1). β_1:regression coefficient for milk yield on lnSCC. β_2: regression coefficient for milk yield on lnSCC squared. β_3: regression coefficient for milk yield on lnSCC cubed. ε_{ijklm}: Residual.]

The analysis was performed using the SAS GLM procedure. The effect of herd and cow was in 'absorbed' statement, the advantage of this procedure is that these effects can be adjusted for before the construction and solution of the rest of the model. Then, we evaluated predicted milk production against a standard level of SCC of 100,000 cells/ml. The estimation of milk production for each cow per year was obtained with Fleishmann's method. The loss per cow and per year was then calculated

The second part concern the economic production model : A single value of predicted loss per cow per year was developed as indicated above. Then, was used as the dependent variable, and management variables collected from the survey were used as independent variables in developing an economic production model that would provide the marginal products associated with mastitis management. A mixed model with SAS was used to take into account the correlation among values of predicted milk loss per cow observed in the same herd. In the first stage, mixed linear models with two effects including one management variable and the random effect of herd , were performed to test simple association between the management variables and the predicted loss per cow. Only management variables with $P \leq .20$ were considered for further analysis by inclusion in a mixed multivariate model.

RESULTS AND DISCUSSION :

The estimate of regression coefficients associated with LnSCC terms were β_1= -2.75 (SE=.52), β_2= .315(SE=.10), and β_3= -.018(SE=.006). As an example, on increase in SCC from 100,000 to 200,000 increased milk loss of 0.6 kg/day (180 kg per lactation). The means of SCC was 326.000 cells/ml (SE= 645.000). Two hundred and ten primiparous (13.03 %) and 324 multiparous (6.41 %) had all test day SCC less than 100 000 cells/ml and so no milk loss was observed. The average of milk loss per lactation and per cow was 135.32 kg SD(50.51), and it represent 7063.25 kg of milk loss/herd/ year (SE = 3990.20).

From all variables, 10 were significant ($P \leq .20$), and were introduced in the second stage of the multivariate model. Because the dependent variable is milk loss measured as a negative number, a negative coefficient indicates a decrease in milk loss, or the increased production resulting from that management strategy, e.g. the farmers who controlled the milking machine yearly (78% of all farmers), had a gain in 20.65 kg of milk/cow/year compared to those who did not ($P = .03$). The type of towel disinfection used between milking varies considerably between farmers, and a higher loss was observed when using quaternary ammonium product 29.74 kg of milk rather than no disinfection ($P = .004$).

Many attempts have been made to estimate the economic importance of mastitis (Bartlett et al., 1990; Miller et al. 1990). However, the comparison of results between different studies is very difficult.(definition and description of mastitis, methods of measurements used, items taken into account by the scientist,, and the origin of the field data). We used a model to evaluate the relationship between physical effect increased SCC, economic effect milk loss and mastitis control strategies. To estimate the relationship between SCC and daily milk yield we used the model developed by Jones and Bartlett . The coefficient of determination (R^2) in our study was .83 indicating that the model predicted 83% of the variation in the milk production as was the case in their study. The regression coefficient values for the LnSCC terms obtained in our study were different from those estimated in Bartlett. This can be explained by the difference in the SCC units used. The results of SCC determination in Bartlett's study were reported in integer units to the nearest 100,000 cells/ml, where as in our study the SCC determination method was more precise, yielding the results in units of 1,000 cells/ml. Our study showed that, on average, the study herds lost an estimated 1.09 kg of milk/cow/day due to cows having SCC greater than 100,000 cells/ml. As the average daily milk yield/cow in our study was 23.35 kg, we can estimate milk loss at approximately 4.5% (1.09/(1.09+23.35)). Our estimation is only slightly different from those of Bartlett et al., 1990, and Raubertas and Shook 1982, who found respectively 1.17 and 1.20 kg of milk loss/cow/day. The means of milk loss per cow and per year associated with increased SCC was 135.32 kg ($\pm$ 50.51). Unfortunately, they do not mention the average loss per cow per year. Our study was based on farms without a mastitis problem, and we take into account only subclinical mastitis. The model assumed to have fixed effects and random variables for each herd. The advantage of this statistical method is that we can take into account herd clustering of data and adjust on potentially individual concomitant variables. By using this model we avoid the approach used by Bartlett et al., 1990 in which they modeled a herd summary variable (herd mean milk loss/cow/year). In the first step of the analysis, six management practice variables had a significant bivariate relation ($p < .10$) with milk loss adjusted by the random effect of herd. In the second step, some of the variables that were initially associated with milk loss failed to remain significant in the final multivariate model (table). This can be explained partially by the relatively small number of herds (171) and by the strong interdependence among management practices. Because, the dependent variable was individual (milk loss/cow/year) we decided to include in the final multivariate model the parity of cows. In the final multivariate model, multiparous cows lost more milk, 71.38 kg/year than primiparous ($P = 10^{-5}$). The milk loss was significantly associated with the frequency of removal of bedding materials ($P = .0012$). When this frequency is inadequate, we observed an increase in milk loss equal to 40.94 kg/cow/year. In studies concerning mastitis, the rate of mastitis was associated with the microbiological contamination of bedding, and dirty cubicles. Apparently, insufficient hygiene in cow housing increases environmental exposure to pathogens, and constitutes an important environmental factor in the incidence of

mastitis. The frequency of the test of milking machine function was associated with milk loss. In herds where milking machines were tested once year, the mean milk loss decreased by 20.65 kg/cow/year compared to those where testing was performed less frequently than once year. The association between milk loss and the use of towel disinfection could be explained that some herds may well be disinfecting towels because of past and present problems with mastitis so, in those herds, disinfection will be positively associated with increasing SCC. Herd that practice disinfection but do not have mastitis problems, will show a negative association with SCC and disinfection. So without knowing why the practice is being maintained, we can not determine which came first (confusion causality with association). By other hand, the second reason why seemingly odd relations appear with some type of disinfection (ammonium quaternary compound being associated with increased SCC and increased milk loss), relates to improper use of the disinfectant. Quaternary ammonium are inactived in organic matrices (feces, milk,...) given that, one would not expect quaternary ammonium compounds to be effective. The use or the choice of the disinfection product by the farmer can be explained by an attempt to remedy other deficiencies in management. The quantitative assessment of the economic effectiveness of mastitis control strategies (at herd level) gives low benefits for subclinical mastitis(at individual cow level). The two principal factors in our study, the frequency of removal of bedding materials and the frequency of milking machine function tests have a marginal beneficial effect, 40.94 and 20.65 kg of milk/cow /year respectively. These improvements represent about 1% of a lactation of 6000 kg. But we do not include in this estimation their positive impact on clinical mastitis. Our results can be used for the cost-benefit analysis.

Table I
Final multivariate production model with marginal value product

variables	Estimate	S.E.	D.F.	t test	*P* value
Intercept	253.05	22.71	7958	11.14	10^{-5}
Parity					
primiparous	-71.38	3.47	7958	-20.56	10^{-5}
multiparous	0				
Air intake					
no	-13.08	7.92	7958	-1.64	.098
yes	0				
Frequency of removal of bedding material					
Adequate	-40.94	16.44	7958	-2.49	.012
Inadequate	0				
Frequency of machine function test					
Yearly					
Less	-20.65	9.56	7958	-2.16	.03
	0				
Towel disinfection with					
Quaternary ammonium	29.74	10.48	7958	2.84	.004
Chlorhexidine	-1.61	9.73		-.17	.868
Acids	22.44	23.84		.94	.346
Others	-26.31	17.75		-1.48	.138
No disinfection	0				

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