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# Risk Factors for Dairy Cow Mastitis in the Central Highlands of Ethiopia

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ABSTRACT

This study, with the objective of assessing the effect of risk factors on dairy cow mastitis in the central highlands of Ethiopia, was undertaken between February and September 2001 in the urban and peri-urban areas of Addis Ababa, Ethiopia. A prevalence study and questionnaire survey were carried out simultaneously. Clinical examination of lactating udders and California mastitis test (CMT) determined clinical and subclinical mastitis, respectively. Risk factors for subclinical and clinical mastitis were identified from data on animals and farm management by chi-square analysis and subsequent logistic regression. Cows aged at least 8 years, with poor body condition, with at least 8 parities and in at least the eighth month of lactation had a significantly higher risk for subclinical mastitis ($p<0.05$). The risk was reduced for cows up to their third parity in good body condition and for cows receiving dry cow therapy. Cows aged at least 4 years, or with at least 8 parities, cows in at least the fourth month of lactation, cows with poor body condition, leaking milk or previous udder infections had a significantly higher risk of clinical mastitis ($p<0.05$). The risk was reduced by the use of separate towels for udder cleaning and by drying off at the end of lactation. Most of the risk factors were in agreement with previous reports. However, stage of lactation and drying-off style were in contrast to others. Further research is needed to identify the interrelationship between production level, specific pathogens and management risk factors.

*Keywords:* Addis Ababa, dairy cows, management, mastitis, peri-urban, risk factors, urban

*Abbreviations:* CMT, California mastitis test; CI, confidence intervals; OR, odds ratio

## INTRODUCTION

Mastitis is a management related disease whose prevention and control depends among other factors on the type of management employed. If management is improved, there is a reduction in the incidence of clinical mastitis and vice versa. As with most infectious diseases, mastitis risk factors depend on three components: exposure to microbes, cow defence mechanisms, and environmental and management

factors (Suriyasathaporn *et al*., 2000). When modern dairy farming in the tropics was first adopted, mastitis was predicted to be an important disease in dairy cattle. Today, most tropical farmers have experienced disaster caused by this disease, and can no longer afford its costs in addition to other burdens (Thirapatsakun, 1989). One of the major tasks of veterinary epidemiology is the identification and quantification of risk factors for animal health and production problems to allow effective control strategies to be adopted (Martin *et al*., 1987).

Questionnaires are commonly applied in epidemiological investigations to collect information on disease occurrence, associated factors, and opinions, and they have been used successfully in studies on mastitis (Schukken *et al*., 1989; Bartlett *et al*., 1992).

Mastitis as a disease, especially the subclinical type, has received increasing attention in Ethiopia (Abdella, 1996; Bishi, 1998; Frese, 1999; Hussein, 1999; Lema *et al*., 2001; Workineh *et al*. 2002; Kerro Dego and Tareke, 2003). Much effort has been focused on the treatment of clinical cases rather than tackling the disease from the control point of view. Information on risk factors of mastitis is of great importance as this is required for the design and implementation of effective prevention and control strategies. Very few papers have been published on the subject of risk factors of mastitis in sub-Saharan Africa. However, adoption of control measures developed for temperate countries may not be successful or economically justified in African countries (Omore *et al*., 1999). This study was designed with the objective of identifying risk factors of mastitis as a guide for the initiation of appropriate and affordable control strategies for the local dairy industry.

## MATERIALS AND METHODS

### *Study farms*

A total of 363 cows from 51 farms from the Ethiopian central highlands were included in this study. They were selected by stratified random sampling from three production systems (urban, periurban and dairy herds in farms situated in secondary towns, e.g. Debre Zeit) from the Addis Ababa Milk Shed (ILCA, 1994).

Overall, the study area is located 1880–2560 m above sea level. It has an average annual temperature of about 21°C. A few places like Debre Zeit have extreme temperatures of about 30°C and above in the dry-season months of September to May. The area has an annual bimodal rainfall estimated at 1800 mm. Study farms included both small-scale ($n$ = 38) and large-scale ($n$ = 13) farms. A farm was judged small if fewer than 10 cows were sampled, and large when at least 10 cows were sampled (Staal and Shapiro, 1995). The farms had predominantly crossbred cows, Friesian–local breed crosses with a very high level of exotic blood. This study was conducted between February and September 2001.

*Study design*

Mastitis

Clinical mastitis was defined by visible signs on clinical examination of lactating udders of the selected cows, whereas California mastitis test (CMT) determined subclinical mastitis cases. A clinical case was positive when a quarter or the entire gland manifested clinical signs (hard and swollen gland, pain on touching and a warmer than normal udder skin, abnormal secretions (blood-tinged milk, clots in milk, or watery milk). Subclinical mastitis was diagnosed on cow or quarter levels if at least one quarter within a cow had a CMT score $\geqslant 1$. CMT scores 'trace' and 'negative' defined healthy quarters (De Graaf and Dwinger, 1996). Bacterial isolation was not attempted on either type of mastitis.

Risk factors

A standardized and pretested questionnaire was used to collect information on risk factors for mastitis. The risk factors were of two types: animal factors and farm-based factors. The respective information on these factors was collected in separate questionnaires designed for each type. The animal-based factors included cow age, breed, parity, lactation stage, body condition score, problems of leaking milk and whether or not the animal in question had previously suffered from mastitis. Farm-based risk factors were dry cow practices (dry cow therapy, dry-off time, and dry-off style), teat drying, teat cleaning, floor types, teat dipping, milkers and bedding.

*Data storage and analysis*

All the collected data were stored and prepared for analysis in Microsoft Access databases. Chi square ($\chi^2$) test using Stata 6.0 (1985–1996) was used to identify and select the risk factors under consideration on the basis of their association with the outcome of interest (subclinical and clinical mastitis). Only those variables with significant associations, as shown from their $\chi^2$- and $p$-values, with the outcome variables were selected. A logistic regression model was then built to illustrate the magnitude of association between the selected factors and mastitis. This was done by deriving odds ratios, $p$-values and 95% confidence intervals of those selected risk factors when entered as explanatory variables against the outcome variable (mastitis). Univariate and multivariate (adjustment of odds ratios for confounding) analyses were done. Odds ratios greater than unity supported by $p$-values less than 0.05 were considered significant. For the univariate analysis, all the selected variables were entered into the model at once. The final output from the multivariate analysis was reported in the same way. The risk factors for use in the logistic regression model were recoded as in Table I.

TABLE I
Recoding of variables for the logistic regression models

| Variable | No. of levels | Code |
|---|---|---|
| Dry cow therapy | | Yes =1, no = 0 |
| Dry-off time | 3 | 1 month before calving, 2 months before calving, 3 when milk turns yellow |
| Dry-off style | | Abrupt = 1, gradual =0 |
| Teat drying | | Separate towel = 1, shared towel = 0 |
| Breed | | |
| Age | 3 | 1–3 years = 1, 4–8 years = 2, >8 years = 3 |
| Parity | 3 | 1st–3rd parity = 1, 4th –7th = 2, >7th = 3 |
| Lactation stage | 3 | 1–3 months = 1, 4–7 months = 2, >7 months = 3 |
| Body condition score | 3 | Good, fair, poor |
| Leaking milk | 2 | Yes = 1, no = 0 |
| Previous udder problem | | Yes = 1, no = 0 |

## RESULTS

### *Prevalence of clinical and subclinical mastitis*

A total of 363 cows with 1452 quarters were randomly sampled from the 51 study herds. Of the 1452 quarters, 54 (3.7 %) were blind/non-functional, leaving 1398 functional quarters (96.3 %). Quarter CMT results indicated that 207, 111, 70, 60 and 950 quarters had CMT scores of 3+, 2+, 1+, 'trace' and negative (0), respectively.

Overall prevalence of subclinical mastitis at cow level was 46.6% (95% CI: 41.3–51.8%). Quarter-level prevalence was 27.8% (95% CI: 25.4–30.2%).

The overall prevalence of clinical mastitis was 6.6%, (95% CI: 4.3–9.7%) at cow level and 2.8% (95% CI: 2–3.8%) at quarter level. There were no significant differences between large-scale and small-scale farms concerning prevalence of subclinical and clinical mastitis.

### *Risk factors for mastitis*

Univariate and multivariate analyses were done for both subclinical and clinical mastitis. Only multivariate results are reported here since the differences between the risk-specific coefficients in the two models were not significant.

## Subclinical mastitis

Age of at least 4 years, cows with at least 8 parities, cows in at least the eighth month of lactation, and poor body condition were significantly ($p < 0.05$) associated with subclinical mastitis. The odds ratios were greater than 1 and the 95% confidence intervals excluded 1 (Table II). A good body condition and cows in first to third lactation had an OR below 1 and the 95% confidence interval excluded 1.

TABLE II
Summary results of multivariate analysis of associations between subclinical mastitis and potential risk factors

| Variable | Level | Odds ratio | *p*-Value | 95% Confidence interval |
|---|---|---|---|---|
| Dry cow therapy | | 0.125 | 0.006 | 0.090– 0.895 |
| Dry off time | | 0.899 | 0.708 | 0.543–1.404 |
| Dry off style | | 0.850 | 0.845 | 0.694–1.068 |
| Teat drying | | 0.592 | 0.241 | 0.536–1.170 |
| Breed | | 1.409 | 0.101 | 0.472–4.210 |
| Age[a] | Middle | 1.117 | 0.043 | 1.234–7.656** |
| | Old | 3.009 | 0.000 | 1.151–12.104** |
| Parity | 1 | 0.725 | 0.803 | 0.583–0.859 |
| | 2 | 0.991 | 0.111 | 0.585–1.336 |
| | 3 | 2.822 | 0.000 | 1.002–3.007** |
| Lactation | Mid | 0.841 | 0.583 | 0.454–1.560 |
| | Late | 1.115 | 0.003 | 1.001–1.212** |
| Body score | Good | 0.699 | 0.903 | 0.321–0.889 |
| | Fair | 1.001 | 0.092 | 0.876–5.339 |
| | Poor | 5.333 | 0.003 | 2.119–13.221** |
| Leaking milk | | 1.432 | 0.313 | 0.347–3.843 |
| Udder problem | | 1.321 | 0.097 | 0.564–1.698 |

[a]Age young 1–3 years dropped

** Significant at 95%CI .

Age was recoded as young 1–3 years, middle 4–8 years and old 8 years and above

Parity was recorded as 1= 1–3, 2 = 4–7, 3 = at least 8

Lactation was recorded as early meaning 1–3, mid 4–7 and late 8 and above

Lactation was measured in months while parity was by count

## Clinical mastitis

Cows aged at least 4 years, cows with at least 8 parities, cows in at least the fourth month of lactation, poor body condition, problem of leaking milk, and a history of udder problems before were significantly associated with clinical mastitis ($p < 0.05$, Table III).

Abrupt drying off at the end of lactation and drying teats with separate towels before milking were protective factors for clinical mastitis (OR < 1, 95% CI excluding 1).

TABLE III
Summary results of multivariate analysis of association between clinical mastitis and potential risk factors

| Variable[a] | Level | Odds ratio | *p*-Values | 95% Confidence interval |
|---|---|---|---|---|
| Dry off time | | 0.785 | 0.348 | 0.173–1.400 |
| Dry off style | | 0.656 | 0.547 | 0.193–0.968 |
| Teat drying | | 0.429 | 0.377 | 0.366–0.857 |
| Breed | | 0.909 | 0.335 | 0.679–1.407 |
| Age[a] | Middle | 1.337 | 0.003 | 1.004–3.216** |
| | Old | 2.544 | 0.000 | 1.885–6.314** |
| Parity[a] | 3 | 1.987 | 0.041 | 1.032–4.426** |
| Lactation[a] | Mid | 2.776 | 0.001 | 1.974–4.536** |
| | Late | 4.815 | 0.000 | 3.201–6.992** |
| Body Score | Good | 1.430 | 0.103 | 0.524–1.983 |
| | Fair | 2.247 | 0.07 | 0.875–4.335 |
| | Poor | 3.563 | 0.008 | 2.035–9.550** |
| Leaking | | 9.001 | 0.000 | 3.747–28.973** |
| Udder problem | | 3.625 | 0.000 | 1.779–9.581** |

**Significant at 95% CI

[a]Dropped variables include young age, early lactation, parity 1 and 2 and dry cow therapy

Age was recoded as young 1–3 years, middle 4–8 years and old at least 8 years

Parity was recorded as 1 = 1–3, 2 = 4–7, 3 = at least 8

Lactation was recorded as early meaning 1–3, mid 4–7 and late at least 8

Lactation was measured in months while parity was by count

## DISCUSSION

This study was undertaken to determine risk factors for clinical and subclinical dairy cow mastitis in the central highlands of Ethiopia. It was not the objective of the study to determine the aetiologic agents. This has been done in several previous studies (Abdella, 1996; Bishi, 1998; Frese, 1999; Hussein, 1999; Workineh *et al*., 2002; Kerro Dego and Tareke, 2003).

Increasing age and parity and poor body condition increased the risk of mastitis. This is in line with previous reports on mastitis in Ethiopia (Hussein, 1999; Kerro Dego and Tareke, 2003) and industrialized countries (Schukken *et al*., 1989; Dulin *et al*., 1998; Suriyasathaporn *et al*., 2000). Stage of lactation was a risk factor for mastitis. In early lactation the risk of clinical mastitis increased, while in late lactation the prevalence of subclinical mastitis increased. Two reports on Ethiopian conditions found higher prevalences of mastitis during early lactation than in late lactation (Hussein, 1999; Kerro Dego and Tareke, 2003). However, they did not differentiate between clinical and subclinical cases.

Body condition so far has not been related to clinical mastitis in tropical countries but good body condition is known to reduce the risk of clinical mastitis in industrialized countries (Edmonson *et al*., 1989; Suriyasathaporn *et al*., 2000). Leaking milk is a well-known risk factor for clinical mastitis in industrialized countries (Schukken *et al*., 1991; Elbers *et al*., 1998; Klaas, 2000; Peeler *et al*., 2000). However, it has not been reported as a risk factor under Ethiopian conditions. Leaking milk may result in increased levels of mastitis pathogens in the environment and an increased exposure of other cows to mastitis pathogens, as bacteria from infected quarters may be present in the milk (Peeler *et al*., 2000). Furthermore, cows that leak milk outside the milking parlour may themselves be at a high risk of mastitis, because they may have wide teat canals that would facilitate the entry of mastitis pathogens into the udder (Lacy-Hubert and Hillerton, 1995). The increase in risk for mastitis in quarters previously affected is well documented in industrialized countries (Eberhart 1986; Edinger *et al*., 1999), but has not been reported so far in tropical countries.

The correct method of drying off is controversial. In high-yielding cows, gradual drying off is recommended. This is because it reduces milk yield at drying off (Dingwell *et al*., 2001). However, milk production in Ethiopian cows is comparatively low, so reduction of milk yield before drying off is not necessary. Dry cow therapy, which is known to reduce the risk of mastitis (Dingwell *et al*., 2001) was performed only in two of the 51 herds under study and therefore was dropped from the analysis for clinical mastitis. The protective effect against mastitis of using separate towels for drying teats has been reported and is a well-established method in reducing spread of contagious pathogens (Dargent-Molina *et al*., 1988). Although bacteriological investigations were not performed in this study, it can be assumed that contagious pathogens like *Staphylococcus aureus* and *Streptococcus agalactiae* play an important role in causing mastitis in the farms studied (Abdella, 1996; Bishi, 1998; Hussein 1999; Workineh *et al*., 2002; Kerro Dego and Tareke, 2003).

Overall, the results of the study show that the risk factors for mastitis in cows that have been determined in other countries also apply for conditions in the central

highlands of Ethiopia. However, owing to the comparatively low milk yield of Ethiopian cows, some aspects have to be extrapolated to Ethiopia with caution. The adoption of control measures developed in temperate countries is not always an economically successful strategy for improving productivity of dairy farming in Africa (Omore *et al.*, 1999). Further prospective studies will determine the impact of the management factors on specific pathogens, the economic losses due to mastitis and the possible benefits from control measures such as teat dipping and dry cow therapy.

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**Facteurs de risque de mastite des vaches laitières dans les hautes terres de l'Éthiopie**

**Résumé** – Cette étude, ayant pour objectif d'évaluer l'effet de facteurs de risque sur la mastite des vaches laitières dans les hautes terres de l'Éthiopie, a été entreprise entre le mois de février et de septembre 2001 dans les zones urbaines et péri-urbaines d'Addis Ababa, en Éthiopie. Une étude de prévalence et une enquête par questionnaire ont été effectuées simultanément. L'examen clinique des pis des vaches allaitantes et le test de la mastite de Californie (CMT) ont décelé une mastite clinique et subclinique, respectivement. Les facteurs de risque de la mastite clinique et subclinique ont été identifiés par analyse Chi-2 et une régression logistique subséquente à partir des données relevées sur les animaux et la gestion des fermes. Les vaches âgées d'au moins 8 ans, de piètre condition corporelle, ayant eu au moins 8 gestes et lors du huitième mois de lactation au moins ont été exposées à un risque considérablement plus élevé de mastite subclinique ($p < 0.05$). Le risque a diminué chez les vaches à leur troisième geste et en bonne condition physique et chez les vaches recevant un traitement pour manque de production de lait. Les vaches âgées d'au moins 4 ans, avec au moins 8 gestes, les vaches se trouvant au moins à leur quatrième mois d'allaitement et en mauvaise condition corporelle, perdant du lait et ayant eu des infections antérieures des pis, ont été exposées à un risque considérablement plus élevé de mastite ($p < 0.05$). Le risque a été diminué par l'utilisation de différentes serviettes pour le nettoyage des pis et par un séchage à la fin de l'allaitement. La plupart des facteurs de risque ont été en accord avec les rapports précédents. Les stades d'allaitement et le style du séchage ont toutefois été différents de ceux mis en uvre par d'autres. Des études plus poussées sont nécessaires pour identifier la relation mutuelle qui existe entre le taux de production, les pathogènes spécifiques et les facteurs de risque liés à la gestion.

**Factores de riesgo para la mastitis de vacas lecheras en las zonas altas centrales de Etiopía**

**Resumen** – Este estudio se efectuó entre febrero y septiembre del 2001 en áreas urbanas y peri-urbanas de Addis Ababa, Etiopía, con el objetivo de evaluar el efecto de los factores de riesgo en la mastitis de vacas lecheras de las zonas altas centrales de Etiopía. Se efectuaron simultáneamente un estudio de incidencia y un cuestionario. El examen clínico de las ubres lactantes y el test de California para la mastitis (CMT) determinaron la existencia de mastitis clínica y sub-clínica, respectivamente. Los factores de riesgo para la

mastitis sub-clínica y clínica fueron identificados a partir de datos de animales y de gestión de granja mediante análisis de chi-cuadrado y regresión logística subsiguiente. Las vacas de al menos 8 años de edad, de condición corporal debilitada, que habían parido al menos 8 veces, y que se hallaban al menos en el octavo mes de lactación tenían un riesgo significativamente más alto de mastitis sub-clínica ($p < 0.05$). El riesgo se reducía para las vacas que habían parido tres veces, que tenían una buena condición corporal, y para vacas que recibían una terapia de secado de vaca. Las vacas de al menos 4 años de edad, que habían parido al menos 8 veces, que se encontraban al menos en el cuarto mes de lactancia, con una condición corporal debilitada, que derramaban leche y habían tenido infecciones de ubre previas, tenían un riesgo significativamente más alto de tener mastitis clínica ($p < 0.05$). El riesgo se redujo mediante el uso de toallas separadas para la limpieza de la ubre y mediante el secado al final de la lactación. La mayoría de los factores de riesgo estaban de acuerdo con los informes previos. Sin embargo, el estadio de la lactación y el estilo del secado contrastaban con otros. Se necesita una mayor investigación para identificar la interrelación existente entre el nivel de producción, los patógenos específicos y los factores de riesgo de la gestión.