

Original Research Article

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Application of Linear Discriminant Function Analysis in Classification of Bovine Mastitis

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ABSTRACT

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The dairy industry is facing a great set back due to high prevalence and incidence of mastitis in milch animals. The aim of this study was to identify the factors discriminating between 'clinical and subclinical mastitis', 'clinical and chronic mastitis' and 'subclinical and chronic mastitis' using linear discriminant function analysis. The present study was conducted at the Large Animal Clinic of Madras Veterinary College (MVC) Hospital, Chennai. Out of two hundred and eighty milch animals examined during the study period, sixty cows were affected by mastitis. Results revealed that while discriminating clinical and subclinical mastitis, the variables named breed of the animal, hand pre-washing prior to milking and udder washing before milking discriminated 0.748, 0.413 and 0.644 times respectively towards subclinical mastitis. Stage of lactation and provision of bedding material discriminated 0.462 and 0.547 times respectively towards clinical mastitis. A total of seven variables was found to be significant for discriminating between clinical and chronic mastitis. Fishers linear discriminant functions obtained might be used to discriminate the further cases of mastitis to be presented in Madras Veterinary College hospital.

Introduction

Mastitis is the most important and expensive disease of dairy industry (Sharif and Muhammad 2009). This disease is characterized by inflammation of mammary gland in response to injury for the purpose of destroying or neutralizing the infectious agents and to prepare the way for healing and return to normal function. Inflammation can be caused by many types of injury including infectious agents and their toxins, physical

trauma or chemical irritants. In the dairy cow, mastitis is always caused by microorganisms, usually bacteria, that invade the udder, multiply in the milk-producing tissues, and produce toxins that are the immediate cause of injury. Elevated leukocytes or somatic cells produced by inflammatory response cause a reduction in milk production and alter milk composition. These changes in turn adversely affect quality and quantity of dairy products (Jones and Bailey 2009).

Contagious mastitis can be divided into three types, clinical mastitis, subclinical mastitis and chronic mastitis (Awale *et al.*, 2012). Clinical mastitis results in alterations of milk composition and appearance, decreased milk production and the presence of the cardinal signs of inflammation (pain, swelling and redness, with or without heat in infected mammary quarters). It is readily apparent and easily detected.

Subclinical infections are those in which no visible changes occur in the appearance of the milk or the udder, but milk production decreases, bacteria are present in the secretion and composition is altered (Jones and Bailey 2009). An inflammatory process that exists for months and may continue from one lactation to another in chronic mastitis (Rabello *et al.*, 2005).

Discriminant function is a multivariate technique for studying the extent to which different groups diverge from one another. The aim of this study was to identify the factors discriminating between 'clinical and subclinical mastitis', 'clinical and chronic mastitis' and 'subclinical and chronic mastitis' using linear discriminant function analysis.

Materials and Methods

The present study was conducted at the Large Animal Clinic of Madras Veterinary College (MVC) Hospital, Chennai. The primary data were collected from milch cows presented in outpatient ward of the MVC hospital. In addition, farm visit of the respective farmers were made to obtain the additional information on bovine management practices followed by the selected farmers.

Total number of animals arrived at the Large Animal Clinic of Madras Veterinary College (MVC) during the study period of four

months from October 2016 to January 2017 was considered as the total population (N) for the present study. Out of two hundred and eighty milch animals examined during the study period, sixty cows were affected by mastitis. Pre-tested questionnaire was prepared and detailed information about mastitis infected animals was collected from the farmers.

Total farm details including details of barn, management aspects, previous history of disease aspects if any and hygienic aspects were collected through personal interview method

Viguiet *et al.*, (2009) stated that the severity of the inflammation could be classified into sub-clinical, clinical and chronic forms. They added that chronic mastitis is a rarer form of the disease, results in persistent inflammation of the mammary gland. Kurjogi and Kaliwal (2014) determined the prevalence of clinical mastitis in cows by examination of changes in the udder, namely, redness, rise in temperature, swelling, hardness of udder, changes in milk colour, and reduction in milk quality and quantity. Subclinical mastitis were confirmed using California mastitis test (CMT). Abebe *et al.*, (2016) used California mastitis test (CMT) as a screening test for sub-clinical mastitis.

The variables which are significantly discriminating the types of mastitis were found out using linear discriminant function. Discriminant analysis were performed by using IBM® SPSS® 20.0 for windows®. Discriminant function is a multivariate technique for studying the extent to which different individuals diverge from one another. The objective of a discriminant analysis is to classify objects, by a set of independent variables, into one of two or more mutually exclusive and exhaustive categories (Alayandand Adekunle, 2015).

Results and Discussion

Factors discriminating between ‘clinical and subclinical mastitis, ‘clinical and chronic mastitis’ and ‘subclinical and chronic mastitis’ were done using linear discriminant function analysis. The variables which are significantly discriminating the types of mastitis were found out by taking two type of mastitis at a time. The results obtained are discussed in separate sub headings.

Factors discriminating between clinical and subclinical mastitis

Table 1 explained the eigen value as 1.620 and canonical correlation as 0.786. Eigen value explained the amount of variance obtained from a function. Square of the canonical correlation value can be considered as R² (co-efficient of multiple determination). That means 61.8 (0.618) percent information about the above said discrimination was being explained by all the independent variables chosen for the study. Rest of the value (1-0.618) is the Wilks’ Lambda. The data generated from 1378 birds on body linear parameters and weight were subjected to discriminant analysis by Gwaza *et al.*, (2013) and estimated group statistics, test of equality of group means, canonical correlation coefficients, Wilks’ lambda, structure matrix and classification statistics.

Co-efficient of discriminant function is given in Table 2. From a total of twenty one independent variables considered, five variables were found to be significant. Breed of the animal, hand pre-washing prior to milking and udder washing before milking discriminated 0.748, 0.413 and 0.644 times respectively towards subclinical mastitis. Shittu *et al.*, (2012) found out the association of subclinical mastitis with breed characteristics. The other two variables named stage of lactation and provision of bedding material discriminated 0.462 and 0.547 times respectively towards clinical mastitis. Linear discriminant function obtained can be used for predicting further discrimination between clinical and subclinical mastitis.

Chi-square values showed that the model was significant at one percent level of significance. 91.1 percent of original grouped cases were correctly classified (predicted) by the discriminant model as seen in Table 3. Milewska *et al.*, (2015) used discriminant model for predicting achievement and failure of pregnancy. They concluded that the discriminant analysis allowed for the creation of a model with a 51.22 percentage correctness of prediction to achieve pregnancy during *in vitro* fertilization treatment and with 74.07 percentage correctly predicted failure of pregnancy.

Table.1 Eigen Values and Wilks' Lambda for all combinations of linear discriminant functions

Type of mastitis	Eigenvalue	Canonical Correlation	Wilks' Lambda	Chi-square
Clinical and Subclinical	1.620	0.786	0.382**	39.007**
Clinical and Chronic	3.883	0.892	0.205**	59.463**
Subclinical and Chronic	1.581	0.783	0.387**	27.021**

Table.2 Standardised co-efficients of discriminants for all the linear discriminant functions

Variables	Discriminant function co-efficient		
	Clinical and Subclinical	Clinical and Chronic	Subclinical and Chronic
Breed of the animal	.748*	.765*	-.672*
Daily milk yield	-.192	.096	.388
Stage of lactation	-.462*	-.149	.463
Lactation number	.133	.620*	.523
Farming system	.517	.217	-.336
Floor space provided per animal	-.312	-.345	-.290
Milking mastitic cow at last or not	-.128	-.291	.346
Udder and leg hygiene score	-.480	-.567	.734
Hygeine of the farm	.643	.909*	.784
Injury to the udder prior to mastitis	.102	.872*	0.890*
Hand pre-washing prior to milking	.413*	-.523*	.613
History of retained placenta (ROP) in current calving	.181	-.222	-1.281
Age of the animal	.123	.338	-.585
Type of milking method adopted	-.228	.148	-.158
Provision of teat dipping	-.138	.211	-.074
Udder washing before milking	.644*	.517	.667*
Udder drying after washing of udder	.505	.432*	1.520
History of metritis in current calving	.052	-.005	-.248
History of mastitis in previous calving	.115	.051	.316
Herd size	.095	-.313	.350
Provision of bedding material	-.547*	-0.987*	-1.103

Table.3 Classification of clinical and subclinical mastitis based on the estimated

Predicted Group Membership				Total
Type of mastitis		Clinical	Sub-clinical	
Count	Clinical	24	4	28
	Sub-clinical	0	17	17
Percentage	Clinical	85.7	14.3	100.0
	Sub-clinical	0	100	100.0

91.1%of original grouped cases correctly classified.

discriminant functions

Table.4 Classification of clinical and chronic mastitis based on the estimated discriminant functions

Predicted Group Membership				Total
Type of mastitis		Clinical	Chronic	
Count	Clinical	26	2	28
	Chronic	0	15	15
Percentage	Clinical	92.9	7.1	100.0
	Chronic	0	100	100.0

95.3%of original grouped cases correctly classified.

Table.5 Classification of subclinical and chronic mastitis based on the estimated discriminant functions

Predicted Group Membership				Total
Type of mastitis		Subclinical	Chronic	
Count	Subclinical	14	3	17
	Chronic	1	14	15
Percentage	Subclinical	82.4	17.6	100.0
	Chronic	6.7	93.3	100.0
87.5% of original grouped cases correctly classified.				

Factors discriminating between clinical and chronic mastitis

Table 1 explained the eigen value as 3.883 and canonical correlation as 0.892. Eigen value explained the amount of variance obtained from a factor. Square of the canonical correlation value can be considered as R² (co-efficient of multiple determination). That means 79.5 (0.795) percent information about the above said discrimination was being explained by all the independent variables chosen for the study. Rest of the value (1-0.795) is the Wilks’ Lambda.

Co-efficient of discriminant function was given in Table 2. From a total of twenty one independent variables considered, seven variables were found to be significant. Breed of the animal, lactation number, hygiene of the farm, injury to the udder prior to mastitis and udder drying after washing of udder discriminated 0.765, 0.620, 0.909, 0.872 and 0.432 times respectively towards chronic mastitis. The other variables including hand pre-washing prior to milking and provision of bedding material discriminated 0.523 and 0.987 times respectively towards clinical mastitis.

Linear discriminant function obtained can be used for predicting further discrimination between clinical and chronic mastitis. Chi-square values showed that the model was significant at one percent level of

significance. 95.3 percent of original grouped cases were correctly classified by the discriminant model as seen in Table 4.

Factors discriminating between subclinical and chronic mastitis

Table 1 explained the eigen value as 1.581 and canonical correlation as 0.783. Eigen value explained the amount of variance obtained from a factor. Square of the canonical correlation value can be considered as R² (co-efficient of multiple determination). That means 61.30 (0.613) percent information about the above said discrimination was being explained by all the independent variables chosen for the study. Rest of the value (1-0.613) is the Wilks’ Lambda.

Co-efficient of discriminant function was given in Table 2. From a total of twenty one independent variables considered, three variables were found to be significant. Injury to the udder prior to mastitis and udder washing before milking discriminated 0.890 and 0.667 times respectively towards chronic mastitis. The breed of the animal discriminated 0.672 times respectively towards subclinical mastitis. Linear discriminant function obtained can be used for predicting further discrimination between subclinical and chronic mastitis. Chi-square values showed that the model was significant at one percent level of significance. 87.5 percent of original grouped cases were

correctly classified by the discriminant model as seen in Table 5. As a conclusion, Fishers linear discriminant functions obtained might be used to discriminate the further cases of mastitis to be presented in Madras Veterinary College hospital.

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