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Logistic Regression Model for the Probability Parameters Estimation of Milk Fever in Dairy Animals in Tamil Nadu, India

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ABSTRACT

Milk fever is occurring in dairy animals during parturient period and management is economically most important, as it results in not only reduction in milk production but also loss of animals In the present study, logistic regression model was employed to estimate the probability of a particular dairy animal affected with milk fever or not. Namakkal and Karur districts of Tamil Nadu were purposively selected for the present study, a total of 83 (64 cow and 19 buffalo) milk fever affected dairy animals were selected through purposive sampling technique from these districts. The log odds of the animal going to be affected by milk fever enhanced by 18.695 and 3.226 times, when breed and parity changed from 0 to 1 (in ceteris paribus). Similarly, when other indicator variables viz., post partum disorders (metritis and retained foetal membrane), summer season and non supplementation of mineral mixture influenced the log odds of the milch animal for being affected by the milk fever were to the tune of 17.908, 2.866 and 74.772, respectively.

Introduction

The livestock sector particularly dairy farming plays a significant role in securing the livelihood of rural farmers by providing income and employment generation in rural areas. However, this sector is facing several disease problems due to introduction of exotic germ plasm for higher productivity and changing global climate which cause huge economic loss resulting from mortality and low productivity of animals (Singh and Shivprasad, 2008). Dairy animals suffer from many diseases; some of these diseases are common with other livestock species, while a few are specific to dairy animals. Metabolic disorders of cattle are a group of diseases that affect dairy cows immediately after parturition. There are several metabolic disorders identified in dairy cows during the first month immediately after parturition. In dairy farming, metabolic diseases such as ketosis, milk fever and downer cow syndrome are the most common expensive disease entities in such lactating dairy animals (Kaneene and Scott, 1990). Among different metabolic diseases, Milk fever is occurring in dairy animals during parturient period and management is economically most important, as it results in not only reduction in milk production but also loss of animals (Thirunavukkarasu *et al.*, 2010). It is an afebrile hypocalcaemic disease of cattle usually associated with immediately after parturition and initiation of lactation. This disease has been known by a number of terms namely parturition paresis, milk fever, parturient apoplexy, eclampsia and paresis peurperalis (Littledike *et al.*, 1981). Further, increasing production of milk after calving places an enormous demand for glucose and minerals at a time when feed intake would not have reached its peak, leading to draining of glucose and calcium from the blood and leaving the milch animal's metabolism under severe stress, as transitions to lactation (Bethard and Smith, 1998). Clinical hypocalcaemia can occur before, during or after calving (Bar and Ezra, 2005). Hypothesis of the present study is that the dairy animal, feeding practices, post partum disorders and other management factors have positive influence on the incidence of milk fever, while the economic losses due to the occurrence of milk fever have the negative influence on profitability of dairy farming. In the present study, it is employed to estimate the probability of a particular dairy animal affected with milk fever or not.

Materials and Methods

Namakkal and Karur districts of Tamil Nadu were purposively selected for the present study, as these districts are experiencing frequent occurrence of milk fever in dairy animals. A total of 83 (64 cow and 19 buffalo) milk fever affected dairy animals were selected through purposive sampling technique from these districts. From the dairy farmers so selected, the data were collected during the months of October 2012 and June 2013 by personal interview method, using pretested interview schedule. The data collected from the sample respondents included information on breed, parity, stage of lactation, frequency of occurrence, stage of calving, feeding practices, milk yield, disease occurrence and post partum disorders were collected. The data so collected were analysed by using of logistic regression model.

The logistic regression model is the technique of choice for analyzing binary response variable in veterinary or human epidemiology. Logistic regression analysis was used to test possible risk factors for development of milk fever in dairy animals by Hosmer and Lemeshow (2000). In the present study, it is employed to estimate the probability of a particular dairy animal affected with milk fever or not. Logistic regression analysis was carried out using SPSS for Window: Release 10.0 (2000). The following logistic regression model is used in this study.

Prob (event) or $P_i = E(Y = 1/V_i)$

$$= \frac{e_\delta + \gamma_1 V_1 + \gamma_2 V_2 + \cdots \ldots + \gamma_i V_i}{1 + e_\delta + \gamma_1 V_1 + \gamma_2 V_2 + \cdots \ldots + \gamma_i V_i}$$

$$i = 1,2,3,\ldots\ldots\ldots,14$$

or, equivalently

$$= \frac{1}{1 + e^{-(\delta + \gamma_1 V_1 + \gamma_2 V_2 + \cdots \ldots + \gamma_i V_i)}}$$

or, simply $= \frac{1}{1 + e^{-z}}$

Where,

δ, γ_i – the coefficients to be estimated from the data;
e – the base of the natural logarithms, approximately 2.718 and
Z – the linear combination such that

$$z = \delta + \gamma_1 V_1 + \gamma_2 V_2 + \cdots \ldots + \gamma_i V_i$$

The probability of the event not occurring is estimated as

Prob (no event) = 1 – Prob (event)

The probability estimates will always be between 0 and 1, regardless of the value of Z. Table 1 shows the description of variables used in logistic regression analysis for metabolic diseases in dairy animals.

Results and Discussion

The probability of bovines picking up of milk fever was assessed by using logistic regression analysis. The outcome of the logistic regression model for milk fever is presented in Table 2. As it could be seen from the table, Wald statistic obtained for the independent variables indicated that the coefficients for breed, parity, post partum disorders, summer season, non supplementation of mineral mixture and species of dairy animal were significant at one per cent level. The coefficient for the variable stage of late lactation was found to be insignificant as per Wald statistic.

From the table it is evident that R statistic for all the variables chosen were positive and it indicated that increase in value of these variables would increase the likelihood of milk fever in respect of their coefficients. The logit, logistic model estimated in the terms of the log of the odds is

$$\text{Log}\left[\frac{\text{Prob (milk fever)}}{\text{Prob (non-milk fever)}}\right] = \log\left[\frac{P_i}{1-P_i}\right]$$

$$= -7.935 + 2.928V_1^{**} + 1.171V_2^{**} - 0.491V_3 - 1.585V_4^{*} - 0.081V_5 + 2.885V_6^{**} + 1.053V_7^{**} - 0.201V_8 - 0.583V_9 + 0.202V_{10} + 4.314V_{11}^{**} - 1.546V_{12}^{**}$$

The log odds of the animal going to be affected by milk fever enhanced by 18.695 and 3.226 times, when breed and parity changed from 0 to 1 (in ceteris paribus). Similarly, when other indicator variables viz., post partum disorders (metritis and retained foetal membrane), summer season and non supplementation of mineral mixture influenced the log odds of the milch animal for being affected by the milk fever were to the tune of 17.908, 2.866 and 74.772, respectively. Milk fever, retained placenta and metritis tend to occur as complex of parturient disorders (Erb and Grohn, 1988). The negative coefficient variable, stage of late lactation indicated that one unit change in late stage of lactation leads to the milk fever occurrence being less likely (0.205 times) to occur. The species, one number of cow changed in the herd leads to the milk fever occurrence being less likely (0.213 times) to occur. The other variables, such as mid stage of lactation, milk yield, winter season, feeding of green fodder and concentrate were found to be non significant. Grohn *et al.*, (1991) were found that the no seasonal pattern for milk fever in logistic analysis. Since it is easier to think of odds rather than log odds, the logistic regression equation can be written in terms of odds as:

- (-7.935 + 2.928V1** + 1.171V2** - 0.491V3 - 1.585V4* - 0.081V5 + 2.885V6 **
+ 1.053V7** - 0.201V8 - 0.583V9 + 0.202V10 + 4.314V11**- 1.546V12**)

$$\frac{P_i}{1-P_i} = e$$

The fitness of the model was assessed by comparing the model's predictions with the observations. Table 3 is the classification table that compares the model's prediction from the observation. It could be seen from the table, 921 observations not affected by milk fever (98.60 per cent of the non affected animals) were correctly predicted by the model not to have milk fever. Similarly, 41 animals affected by milk fever (50.60 per cent to the total animal affected by milk fever) were correctly predicted to be affected by milk fever. Overall 94.80 per cent of the observations were correctly classified.

Table.1 Description of variables used in logistic regression analysis for milk fever in dairy animals

Explanatory variables	Levels	Specifications	X_i
Breed	Non-descript; Crossbred cow / Graded buffalo	1-Crossbred Cow/ Graded Buffalo; 0-Otherwise	X_1
Parity (Order of lactation)	Continuous	In number of calving	X_2
Stage of lactation [a]	Early stage; Mid stage; Late stage	1-if Mid; 0-Otherwise	X_3
		1-if Late; 0-Otherwise	X_4
Average daily milk yield	Continuous	Litres per day	X_5
Post-partum disorders (metritis and retained foetal membrane)	Present; Absent	1-if Present; 0-Otherwise	X_6
Season [b]	Summer; Winter; Monsoon	1-if Summer; 0-Otherwise	X_7
		1-if Winter; 0-Otherwise	X_8
General appearance	Debilitated, Healthy	1-if Debilitated; 0-Otherwise	X_9
Previous occurrence of metabolic diseases	Present; Absent	1-if Present; 0-Otherwise	X_{10}
Green fodder feeding	Not practiced; Practiced	1-if Not practiced; 0-Otherwise	X_{11}
Concentrate feeding	Not practiced; Practiced	1-if Not practiced; 0-Otherwise	X_{12}
Supplementation with mineral mixture	Not practiced; Practiced	1-if Not practiced; 0-Otherwise	X_{13}
Proximity to parturition (near term)	Yes; No	1-if Yes; 0-Otherwise	X_{14}
Species of dairy animal	Cow; Buffalo	1-if Cow; 0-Otherwise	X_{15}

[a] reference category: Early lactation; [b] reference category: monsoon.

Table.2 Parameters estimated for the logistic regression model for milk fever

S. No.	Variables	Estimated coefficient	Standard error	Wald statistic	R statistic	Exp (B)
1.	Breed	2.928	0.809	13.101**	0.000	18.695
2.	Parity (Order of lactation)	1.171	0.273	18.368**	0.000	3.226
3.	Stage of lactation 2	-0.491	0.392	1.565	0.211	0.612
4.	Stage of lactation 3	-1.585	0.743	4.549*	0.033	0.205
5.	Average daily milk yield	-0.081	0.067	1.457	0.227	0.922
6.	Post partum disorders (metritis and retained foetal membrane)	2.885	0.454	40.306**	0.000	17.908
7.	Season summer	1.053	0.279	14.235**	0.000	2.866
8.	Season winter	-0.201	0.304	0.437	0.508	0.818
9.	Feeding of green fodder	-0.583	0.532	1.203	0.273	0.558
10.	Feeding of concentrate	0.202	0.554	0.132	0.716	1.223
11.	Supplementation with mineral mixture	4.314	0.428	101.524**	0.000	74.772
12.	Species of dairy animal	-1.546	0.442	12.227**	0.000	0.213
13.	Constant	-7.935	1.769	20.121	0.000	0.000

*significant at 5 per cent level of probability
**significant at 1 per cent level of probability
Note: degree of freedom for each variable is 1

Table.3 Comparison of prediction of the logistic regression analysis to the observed outcomes (classification table) for milk fever

Observed	Predicted		Per cent correct
	Non affected (0)	Affected (1)	
Non affected (0)	921	13	98.60
Affected (1)	40	41	50.60
Overall	**961**	**54**	**94.80**

Conclusion of the study is as follows:

As per Wald statistic obtained for the independent variables indicates that the coefficients for breed, parity, post partum disorders, summer season, non supplementation of mineral mixture and species of dairy animal were significant. The coefficients for the variable stage of late lactation was found to be insignificant. These findings insist the importance of milk fever among dairy stock holders and bring to lime light the various causes of milk fever to avoid huge economic loss in dairy animals.

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