

*Original Research***Logistic Regression Model for the Predisposing Factors for Occurrence of Ketosis in Dairy Animals in Karur and Namakkal Districts of Tamil Nadu****V. Senthilkumar**

Assistant Professor, Department of Animal Husbandry Economics Veterinary College and Research Institute, Namakkal, Tamil Nadu Veterinary and Animal Sciences University, Tamil Nadu, INDIA

*Corresponding author: senthilae@gmail.com

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Abstract

Ketosis disease condition cause severe economic losses in terms of heavy reduction in milk yield. In the present study, logistic regression model was employed to estimate the probability of a particular dairy animal affected with ketosis or not. Namakkal and Karur districts of Tamil Nadu were purposively selected for the present study, a total of 30 (22 cow and 8 buffalo) ketosis affected dairy animals were selected through purposive sampling technique from these districts. The log odds of the animal going to be affected by ketosis increased by 9.526 times, when the parity of the animal was changed from 0 to 1. When other indicator variable namely stage of mid lactation influenced the log odds of the milch animal for being affected by the ketosis was at the tune of 110.002 times and one unit increase in milk yield would favour the occurrence of ketosis by 3.00 per cent.

Key words: Ketosis, Logistic regression and Probability

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Introduction

The prevalence of animal diseases in the world has been reduced in the last four decades due to its economic importance; there are still some of the livestock diseases that cause reduction in production efficiency leading to severe economic losses (Johnchristy and Thirunavukkarasu, 2006). 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 Hurd, 1990). Among these metabolic disorders, Ketosis disease condition cause severe economic losses in terms of heavy reduction in milk yield and impaired reproductive performance. Ketosis is a metabolic disorder that occurs in cattle when energy demands exceed energy intake and result in a negative energy balance. Ketotic cows often have low blood glucose concentrations. Ketosis can cause economic losses through decreased milk production

and may occur in association with pre parturient diseases by Asl *et al.* (2011). Hypothesis of the present study is that the dairy animal, environment, feeding practices and other management factors have positive influence on the incidence of ketosis, while the economic losses due to the occurrence of ketosis 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 ketosis 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 ketosis in dairy animals. A total of 30 (22 cow and 8 buffalo) ketosis affected dairy animals were selected through purposive sampling technique from these districts. In order to choose households, specifically owning ketosis affected dairy farms were identified by case registers of veterinary dispensaries and clinics of Veterinary College and Research Institute, Namakkal and practicing private veterinary doctors both in Namakkal and Karur districts were consulted and prepared the list of dairy farmers. 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 ketosis in dairy animals (Hosmer and Lemeshow, 2000). In the present study, it is employed to estimate the probability of a particular dairy animal affected with ketosis 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.

$$\text{Prob (event) or } P_i = E(Y = 1/V_i) = \frac{e^{\delta + \gamma_1 V_1 + \gamma_2 V_2 + \dots + \gamma_i V_i}}{1 + e^{\delta + \gamma_1 V_1 + \gamma_2 V_2 + \dots + \gamma_i V_i}}$$

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

or, equivalently

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

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

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

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

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.

Table 1: Description of variables used in logistic regression analysis for metabolic diseases 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.

Result and Discussion

The probability of bovines picking up of ketosis was assessed by using logistic regression analysis. The outcome of the logistic regression model for ketosis 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 parity, stage of mid lactation, milk yield, post partum disorders were significant. The coefficients for the variables, breed, late stage of lactation, season, health status of the animal, previous occurrence of metabolic diseases, feeding of green fodder and concentrate and species of dairy animal were found to be insignificant as per Wald statistic. As the contribution of individual independent variables to the dependent variables in the logistic model cannot be determined, the partial correlation between the dependent and independent variables, which ranges from -1 to +1 were estimated through R 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 ketosis to the tune of their coefficients. The logit equation implied that the logistic coefficient could be interpreted on the change in the log odds associated with a one unit change in the independent unit. The rearrangement of logistic equation obtained in terms of the odds of the event occurring was essential for interpreting the logistic regression coefficients estimated. The logit, logistic model estimated in the terms of the log of the odds is-

$$\text{Log} \frac{\text{Prob}(\text{ketosis})}{\text{Prob}(\text{non} - \text{ketosis})} = \text{Log} \frac{P_i}{1 - P_i}$$

$$= - 2.379 + 29.564V_1 + 2.254V_2^* + 4.700V_3^{**} + 2.635V_4 + 1.071V_5^* + 3.973V_6^{**} - 1.597V_7 - 1.162V_8 + 0.009V_9 + 1.531V_{10} - 27.563V_{11} - 1.370V_{12} - 55.026V_{13}$$

The log odds of the animal going to be affected by ketosis increased by 9.526 times, when the parity of the animal was changed from 0 to 1 (in ceteris paribus). Similarly, when other indicator variable namely stage of mid lactation influenced the log odds of the milch animal for being affected by the ketosis was at the tune of 110.002 times. On the other hand, one unit change in the factor post partum disorders (metritis and retained foetal membrane) would make the event 53.149 times as likely to occur, respectively. The results further implied that one unit increase in milk yield would favour the occurrence of ketosis by 3.00 per cent. This finding was also in accorded with Melendez *et al.* (2006) and Duffield *et al.* (2003). The season, health status, previous occurrence of metabolic diseases, feeding of green fodder and concentrate and species of dairy animal had no impact on the occurrence of ketosis as shown in the Table. Since it is easier to think of odds rather than log odds, the logistic regression equation can be written in terms of odds as:

$$P_i / (1 - P_i) = e^{(-2.379 + 29.564V_1 + 2.254V_2^* + 4.700V_3^{**} + 2.635V_4 + 1.071V_5^* + 3.973V_6^{**} - 1.597V_7 - 1.162V_8 + 0.009V_9 + 1.531V_{10} - 27.563V_{11} - 1.370V_{12} - 55.026V_{13})}$$

$$P_i = e^{(-2.379 + 29.564V_1 + 2.254V_2^* + 4.700V_3^{**} + 2.635V_4 + 1.071V_5^* + 3.973V_6^{**} - 1.597V_7 - 1.162V_8 + 0.009V_9 + 1.531V_{10} - 27.563V_{11} - 1.370V_{12} - 55.026V_{13})}$$

$$P_i = e^{(-2.379 + 29.564V_1 + 2.254V_2^* + 4.700V_3^{**} + 2.635V_4 + 1.071V_5^* + 3.973V_6^{**} - 1.597V_7 - 1.162V_8 + 0.009V_9 + 1.531V_{10} - 27.563V_{11} - 1.370V_{12} - 55.026V_{13})}$$

The e raise to the power is γ_i , the factor by which the odds changed when the i^{th} independent variable increases by one uni. If γ_i is positive, this factor will be greater than 1 which means that the odds are increased; if γ_i is negative, the factor will be less than 1, which means that the odds are decreased. When γ_i is 0, the factor equals 1, which leaves the odds unchanged.

Table 2: Parameters estimated for the logistic regression model for ketosis

S. No.	Variables	Estimated coefficient	Standard error	Wald statistic	R statistic	Exp (B)
1.	Breed	29.564	1636.228	0.000	0.986	6.908
2.	Parity (Order of lactation)	2.254	1.026	4.823*	0.028	9.526
3.	Stage of lactation 2	4.700	1.599	8.645**	0.003	110.002
4.	Stage of lactation 3	2.635	1.589	2.750	0.097	13.943
5.	Average daily milk yield	1.071	0.431	6.169*	0.013	0.343
6.	Post partum disorders (metritis and retained foetal membrane)	3.973	1.327	8.960**	0.003	53.149
7.	Season summer	-1.597	1.419	1.268	0.260	0.202
8.	Season winter	-1.162	1.426	0.664	0.415	0.313
9.	General appearance	0.009	1.947	0.000	0.996	1.010
10.	Previous occurrence of metabolic diseases	1.531	1.691	0.820	0.365	4.624
11.	Feeding of green fodder	-27.563	1636.229	0.000	0.987	0.000
12.	Feeding of concentrate	-1.370	1.206	1.290	0.256	0.254
13.	Species of dairy animal	-55.026	1935.684	0.001	0.977	0.000
14.	Constant	- 2.379	6.703	0.126	0.723	0.093

*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

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, 985 observations not affected by ketosis (99.80 per cent of the non affected animals) were correctly predicted by the model not to have ketosis. Similarly, 22 animals affected by ketosis (81.50 per cent to the total animal affected by ketosis) were correctly predicted to be affected by ketosis. Overall 99.30 per cent of the observations were correctly classified.

Table 3: Comparison of prediction of the logistic regression analysis to the observed outcomes (classification table) for ketosis

Observed	Predicted		Per cent correct
	Non Affected (0)	Affected (1)	
Non affected (0)	985	2	99.80
Affected (1)	5	22	81.50
Overall	990	24	99.30

Conclusion

As per Wald statistic obtained for the independent variables indicates that the coefficients for parity, stage of mid lactation, milk yield and post partum disorders were significant. The coefficients for the variables, breed, late stage of lactation, season, health status of the animal, previous occurrence of metabolic diseases, feeding of green fodder and concentrate and species of dairy animal were found to be insignificant. These findings insist the importance of ketosis among dairy stock holders and bring to lime light the various causes of ketosis to avoid huge economic loss in dairy animals.

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