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# Forecasting of Enterotoxaemia Outbreak in Small Ruminants

**G. Selvaraju**
Associate Professor,
Department of Veterinary Epidemiology and Preventive Medicine,
Veterinary College and Research Institute, Namakkal – 637 002, Tamil Nadu, India
Email: g.selvaraju@tanuvas.org.in

***Abstract* – A study was undertaken to develop forecasting model for prediction of enterotoxaemia outbreak in North-west agroclimatic zone of Tamil Nadu, India. In this study, fourteen enterotoxaemia outbreaks were identified of which nine and five by active and surveillances respectively and used. Meteorological data comprising of maximum and minimum temperatures, relative humidity, rainfall and wind speed were collected and used as the multiple predictor variables in the multiple liner regression model through Statistical Package for Social Survey (SPSS) ®15.00 for windows. A multiple liner regression model was developed which is qualitatively valid for North-west zone of Tamil Nadu. Value of dependant variable is less than or greater than one, which indicates that a remote or more chance of enterotoxaemia outbreak respectively. Monthly mean maximum temperature, monthly mean minimum temperature, monthly mean relative humidity at 8.30 hours IST, monthly mean relative humidity at and 17.00 hours IST, monthly total rainfall and monthly mean wind speed of 29.1 – 31.0°C, 19.1 – 21.0°C, 80.1 – 85.0%, 60.1 – 70.0%, 101 – 200mm and 3 – 6 km/h respectively are identified as the ideal climate for more number of enterotoxaemia outbreaks in this zone. Based on that stake holders will be advised to institute suitable prophylactic measures through media to avoid economic losses due to outbreak of enterotoxaemia.**

***Keywords* – Agroclimatic Zone, Enterotoxaemia, Forecasting Model, Meteorological Data, Multiple Linear Regression.**

## I. Introduction

Enterotoxaemia caused by *Clostridium perfringens* type D is a disease of great economical and sanitary importance for sheep and goat farming worldwide [1] due to a high fatality rate, decreased productivity, and increased treatment costs [2]. It is may be seen in animals of any age, but mostly common in lambs that are either less than two weeks old or weaned in feedlots. The highest incidence of the disease was recorded in suckling lambs between the age of three and ten weeks [3], [4], and same age group in kids and calves between one and four months.

Weather can modulate the persistence, expression and temporal and spatial distribution of enterotoxaemia either directly or indirectly. Timely announcement of weather forecasting is a useful tool for sheep and goat owners [5] to carry out disease control activities to contain the outbreak in the most cost-effective way. Hence, a study work was carried out to develop an effective forecasting model for prediction of enterotoxaemia outbreak in North-west agroclimatic zone of Tamil Nadu, India.

## II. Materials and Methods

### *A. Study zone*

Tamil Nadu located in the peninsular Deccan Plateau of India and divided into seven agroclimatic zones: Cauvery Delta, North-East, West, North-West, High Altitude, South and high rainfall zones based on soil characteristics, rainfall distribution, irrigation pattern, cropping pattern and other ecological and social characteristics. The study was carried out in sheep and goat farms located in the North-west agroclimatic zone of Tamil Nadu, India.

### *B. Outbreak data*

Enterotoxaemia outbreak particulars were collected by both active and passive surveillances [6] in this zone and used in this study.

### *C. Active Surveillance*

A total of nine outbreaks were identified through active surveillance for a period of two years (June 2007 to May 2009). Outbreak flocks were identified based on the history and clinical symptoms. Intestinal contents were collected from sheep and goats with suspected enterotoxaemia during post-mortem examinations. Control samples were collected from healthy sheep and goat slaughtered at the abattoir for determining the background level activity of these toxins present in normal intestinal contents [4]. All the samples were subjected to a commercial indirect enzyme linked immunosorbent assay kit (BIO-X diagnostics, Belgium) for the detection of alpha-, beta- and epsilon-toxin of *Clostridium perfringens*.

### *D. Passive Surveillance*

A total of five outbreaks were identified through passive surveillance for period of twelve years (June 1997 to May 2009) with the help of Animal Disease Investigation Units, Salem and Dharmapuri districts of Tamil Nadu, India.

### *E. Meteorological data*

Meteorological data comprising of monthly mean maximum and minimum temperature, relative humidity at 8.30 h IST and 17.00 h IST, monthly total rainfall and monthly mean wind speed for the period from June 1997 to May 2009 were collected from Animal Feed Analytical and Quality Control Laboratory, Veterinary College and Research Institute, Namakkal, Tamil Nadu and Regional Meteorological Centre, Indian Meteorological Department, Chennai, Tamil Nadu and used in this study. Table 1 and 2 are shows that categorized meteorological data and number of enterotoxaemia outbreaks.

### *F. Calculation and Statistical analysis*

Statistical Package for Social Survey (SPSS) ®15.00 for windows, available in Tamil Nadu Veterinary and Animal

Sciences University, Chennai, Tamil Nadu was used in this study as applied by plant pathologist Esker [7] and validated with existing data.

Multiple linear regression generalises this methodology to allow for multiple predictor variables, such as monthly mean maximum temperature, monthly mean minimum temperature, relative humidity (at 8.30 h IST), relative humidity (at 8.30 h IST), monthly total rainfall and wind speed.

Multiple linear regression model used as follows

$$y = \beta_0 + \beta_1 w_1 + \beta_2 w_2 + \beta_3 w_3 + \beta_4 w_4 + \beta_5 w_5 + \beta_5 w_5 + \beta_6 w_6$$

Where,

y - Dependant variable

$\beta_0$ – Constant

$\beta_{(1\text{-}6)}$ – Unstandardised coefficient for each predictor variables

Predictor variables:

$w_1$ - Monthly mean maximum temperature (°C)

$w_2$ - Monthly mean minimum temperature (°C)

$w_3$ - Relative humidity at 8.30 h IST (per cent)

$w_4$ - Relative humidity at 17.00 h IST (per cent)

$w_5$ – Monthly total rainfall (mm)

$w_6$ – Monthly mean wind speed (km/h)

## III. RESULTS

Multiple linear regression model for forecasting of enterotoxaemia out break in North-west agroclimatic zone of Tamil Nadu, India as follows,

$$y = (-93.701) + (3.405\, w_1) + (-2.165\, w_2) + (-0.489\, w_3) + (1.389\, w_4) + (-0.015\, w_5) + (0.761\, w_6)$$

Model summary and regression co-efficient are shown in Table 3. This model is developed with following predictor variables working range and it is fixed based on the climatic condition prevailed over past 12 years.

Monthly mean maximum temperature (°C): 29.12 – 36.73
Monthly mean minimum temperature (°C): 18.43 – 24.41
Relative humidity at 8.30 h IST (per cent): 69.17 – 82.42
Relative humidity at 17.00 h IST (per cent): 42.33 – 67.83
Monthly total rainfall (mm): 1.31 – 409.20
Monthly mean wind speed (km/h): 1.33 – 8.20

## IV. DISCUSSION

### *A. Forecasting model*

In this model, preceding 30 days average of predictor variables on daily basis is used to give early warning. The model is qualitatively valid only for this zone within the working range. If the value of dependant variable is less than one (y<1) there is a remote chance for enterotoxaemia outbreak and if greater than one (y>1) there is a more chance for enterotoxaemia outbreaks as said by Jong [8]. Based on that stake holders will be advised to institute suitable prophylactic measures through media to avoid economic losses due to diseases.

### *B. Correlation of meteriological data with outbreaks*

#### *B.1. Monthly mean temperature with Enterotoxaemia outbreaks*

In this zone, enterotoxaemia outbreaks were more when the monthly mean maximum and minimum temperatures ranges from 29.1 – 31.0°C and 19.1 – 21.0°C respectively. Similarly, Mannan [9] opined that cold weather stress and a concomitant infestation with coccidia were suggested as possible predisposing factors in an outbreak of enterotoxaemia.

#### *B.2. Monthly mean relative humidity with Enterotoxaemia outbreaks*

More numbers of enterotoxaemia outbreaks were identified at monthly mean relative humidity of 80.1 – 85.0% and 60.1 – 70.0% at 8.30 hours IST and 17.00 hours IST respectively. Present study reveals that relative humidity is positively correlated. This finding corroborates with the reports of Javed [10] who found that the occurrence of disease was associated with humid weather with rain.

#### *B.3. Monthly total rainfall with Enterotoxaemia outbreaks*

Outbreaks were more with monthly total rainfall ranges from 101 to 200 mm, which indicates moderate level of rainfall favours excess supply of lush green pasture and fodder contamination with soil. Songer [11] opined that enterotoxaemia arises mainly at the beginning of the rainy season, associated with an oversupply of young fresh fodder plants. The disease can occur following rain in set stocked flocks and in flocks newly introduced to lush pastures [3].

#### *B.4. Monthly mean wind speed with Enterotoxaemia outbreaks*

Fifty percentage of outbreak occurred with wind speed of 3 – 6 km/h. This is not directly correlated. However, wind prevailing during monsoon season affects the outbreak.

## V. CONCLUSION

In agricultural sciences, several models were developed for the forecasting of plant diseases. But in veterinary sciences forecasting models are scanty especially in India. In the present study, meterological parameters are correlated with outbreak, a multiple linear regression model for enterotoxaemia and validated with available data. This is a pioneer model for the North-west agroclimatic zone of Tamil Nadu, India.

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## AUTHOR'S PROFILE

**Dr. G. Selvaraju**

was born on July 26, 1974 in Namakkal city, Tamil Nadu, India. He achieved the B.V.Sc. degree in 1997, M.V.Sc. degree in 2000 and Ph.D. in 2010 from Veterinary College and Research Institute, Namakkal, Tamil Nadu, India. He has received four gold medals for his excellent research work on "Development of forecasting model against diseases of small ruminants". He is working in the capacity of Associate Professor in Tamil Nadu Veterinary and Animal Sciences University, Chennai, Tamil Nadu, India. He has published more than 25 research articles in reputed journals.

Table 1: Categorized monthly mean maximum and minimum temperatures and monthly mean RH 8.30 h IST and number of enterotoxaemia outbreaks

| **Meterological Parameter** | | **Number outbreak** |
|---|---|---|
| **Element** | **Categorized Values** | |
| Monthly mean maximum temperature | 29.1 - 30.0 | 4 |
| | 30.1 – 31.0 | 5 |
| | 31.1 – 32.0 | 0 |
| | 32.1 – 33.0 | 0 |
| | 33.1 – 34.0 | 1 |
| | 34.1 – 35.0 | 1 |
| | 35.1 – 36.0 | 0 |
| | 36.1 – 37.0 | 0 |
| Monthly mean minimum temperature | 18.1 – 19.0 | 0 |
| | 19.1 – 20.0 | 0 |
| | 20.1 – 21.0 | 5 |
| | 21.1 – 22.0 | 4 |
| | 22.1 – 23.0 | 0 |
| | 23.1 – 24.0 | 1 |
| | 24.1 – 25.0 | 1 |
| Monthly mean RH 8.30 h IST | 65.1 – 70.0 | 0 |
| | 70.1 – 75.0 | 0 |
| | 75.1 – 80.0 | 1 |
| | 80.1 – 85.0 | 10 |

Table 2: Categorized monthly mean RH 17.00 h IST, monthly total rainfall and monthly mean wind speed and number of enterotoxaemia outbreaks

| Meterological Parameter | | Number outbreak |
|---|---|---|
| **Element** | **Categorized Values** | |
| Monthly mean RH 17.00 h IST | 40.1 – 45.0 | 0 |
| | 45.1 – 50.0 | 1 |
| | 50.1 – 55.0 | 0 |
| | 55.1 – 60.0 | 1 |
| | 60.1 – 65.0 | 0 |
| | 65.1 – 70.0 | 9 |
| Monthly total rainfall | 0 - 100 | 7 |
| | 101 – 200 | 4 |
| | 201 – 300 | 0 |
| | 301 – 400 | 0 |
| | 401 - 500 | 0 |
| Monthly mean wind speed | 1.1 – 2.0 | 1 |
| | 2.1 – 3.0 | 1 |
| | 3.1 – 4.0 | 4 |
| | 4.1 – 5.0 | 4 |
| | 5.1 – 6.0 | 0 |
| | 6.1 – 7.0 | 0 |
| | 7.1 – 8.0 | 0 |
| | 8.1 – 9.0 | 1 |

Table 3: Model summary and regression coefficient for the developed model

| Model | R | R Square | Adjusted R Square | Change Statistics | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | R Square Change | F Change | df1 | df2 | Sig. F Change |
| 1 | .897[a] | .804 | .569 | .804 | 3.418 | 6 | 5 | .099 |

a. Predictors : (Constant), Monthly mean maximum temperature (°C), Monthly mean maximum temperature (°C), Relative humidity (RH) at 8.30 h IST (%), Relative humidity (RH) at 17.00 h IST(%),Monthly total rainfall (mm), Monthly mean wind speed (km/h)

**Regression Coefficient[a]**

| S. No. | Model | Unstandardised Coefficient | | Standardised Coefficient | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1. | (Constant) | -93.701 | 111.035 | | -.844 | .437 |
| 2. | Monthly mean maximum temperature | 3.405 | 3.725 | 1.256 | .914 | .403 |
| 3. | Monthly mean minimum temperature | -2.165 | 3.081 | -.691 | -.703 | .514 |
| 4. | Monthly mean RH (8.30 h IST) | -.489 | .666 | -.317 | -.734 | .496 |
| 5. | Monthly mean RH (17.30 h IST) | 1.389 | .660 | 2.020 | 2.100 | .090 |
| 6. | Monthly total rainfall (mm) | -.015 | .017 | -.276 | -.873 | .423 |
| 7. | Wind speed (km/h) | .761 | 1.277 | .215 | .596 | .577 |