

Spatio-Temporal Epidemiological Analysis of Livestock Diseases - A Case of Tamil Nadu State in India

Krishnamoorthy. P*, Govindaraj. G, Shome. B.R and Rahman. H

ICAR-National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI),
Bengaluru, Karnataka 560064, INDIA

*Corresponding author: krishvet@gmail.com

Rec. Date:	Jul 28, 2016 03:23
Accept Date:	Aug 04, 2016 05:56
Published Online:	August 06, 2016
DOI	10.5455/ijlr.20160804055652

Abstract

In the present study, spatio-temporal analysis of eight livestock diseases was undertaken for Tamil Nadu state in India. Data (2002-14) on outbreaks, diagnosed cases, death cases were collected and analyzed for cumulative outbreaks, year, seasonal and zone wise and calculated prevalence, mortality and case fatality rates (CFR). Cumulative outbreaks revealed Anthrax (109) was high followed by Foot and mouth disease [FMD] (99), Peste des petits ruminants [PPR] (45) and other diseases. Season wise analysis revealed increased outbreaks during North east monsoon. Agroclimatic zone and cluster analysis revealed highest outbreaks occurred in Northeastern and South zones. Prevalence rate was high in FMD (4.37) and low in BQ, ET (0.005). Mortality and CFR were highest in PPR (1.97) and Anthrax (96.71%) and lowest in BQ, ET (0.04) and FMD (11.79%), respectively. Bio-climatographs showed relationship between rainfall and disease outbreaks. Thus, preventive vaccinations against anthrax, FMD, PPR have to be initiated in two zones before monsoon to mitigate livestock diseases in Tamil Nadu and boost economy.

Key words: Spatio-Temporal Analysis, Epidemiology, Livestock Diseases, Tamil Nadu

How to cite: Krishnamoorthy, P., Govindaraj, G. N., Shome, B. R. & Rahman, H. (2016) Spatio-Temporal Epidemiological Analysis of Livestock Diseases - A Case of Tamil Nadu State in India. *International Journal of Livestock Research*, 6 (8), 27-38. [doi:10.5455/ijlr.20160804055652](https://doi.org/10.5455/ijlr.20160804055652)

Introduction

The scope of epidemiology in modern animal husbandry practice is continuously widening. Epidemiological analysis of data on various livestock diseases will be prerequisite for planning, execution and monitoring of livestock disease control programmes. The epidemiological analysis of various diseases affecting livestock is important since it causes economic losses to the farmers and affects the economy of the country. Tamil Nadu, a state in south India, comprises 32 districts with total livestock population of 22.72 million consisting of 8.81, 0.78, 4.78 and 8.14 million of Cattle, Buffalo, Sheep and Goat, respectively as per 19th livestock census 2012 (BAHS, 2014). Infectious diseases are of critical

importance in livestock production systems based economy, since disease reduces growth and productivity. Tamil Nadu state continues to experience outbreaks of anthrax, black quarter (BQ), foot and mouth disease (FMD), haemorrhagic septicemia (HS) in large ruminants (cattle and buffaloes) and peste des petits ruminants (PPR), bluetongue (BT), enterotoxaemia (ET), sheep and goat pox in small ruminants (sheep and goats) despite implementation of vaccination programmes sponsored by State and Central Governments. To effectively combat the threats posed by the various livestock diseases, there is a need for clear understanding of the epidemiology of the livestock diseases (Perry *et al.*, 2002). The goal of an epidemiological study is to identify the important risk factors that need to be taken into consideration in the development of effective preventive and control measures. Despite the importance of epidemiological analysis very few reports are available. Further, spatio-temporal epidemiological analysis of livestock diseases for Tamil Nadu state is lacking. Hence, the present study on spatio-temporal epidemiological analysis of eight economically important livestock diseases namely four bacterial and four viral diseases were undertaken for Tamil Nadu state during the period April 2002 to March 2014.

Materials and Methods

Tamilnadu State

Tamil Nadu State is situated at the South-eastern extremity of the Indian peninsula bounded on the north by Karnataka and Andhra Pradesh, in the East by Bay of Bengal, in the South by Indian Ocean and in the West by Kerala State. It lies between 8.5' and 13.35' at northern latitude and 76.15' and 80.20' of eastern longitude with an area of 1, 30,069 sq. km (50,154.7 sq. miles).

Data Collection Methodology

The spatio-temporal data was collected from annual reports of Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, New Delhi and Directorate of Animal Husbandry and Veterinary Services, Tamil Nadu. In this study, a outbreak is considered when animals showed clinical signs or lesions characteristic of anthrax, BQ, BT, ET, FMD, HS, PPR, sheep and goat pox, but some instances, there was supportive laboratory confirmation (Rosenberger, 1979, Samad, 2000). The secondary data on eight livestock diseases viz., anthrax, BQ, BT, ET, FMD, HS, PPR, Sheep and Goat pox namely, outbreaks, diagnosed cases, death cases, village, district, month, year were collected for the period April 2002 to March 2014 as per prescribed protocol (Martin *et al.*, 1994). The district level livestock population was collected from 19th Livestock Census 2012 report (BAHS, 2014).

Spatio-temporal Epidemiological Analysis

The year wise analysis of the livestock disease outbreaks occurred was carried to assess the disease trend. The season wise analysis was carried out for eight diseases and each year was classified into four seasons (summer [April, May], Southwest monsoon [June, July, and August], Northeast monsoon [September, October, November, December] and winter [January, February, March]). Based on soil characteristics, rainfall distribution, irrigation pattern, cropping pattern and other ecological and social characteristics, the Tamil Nadu State has been classified into seven agro climatic zones (Cauvery delta [Ariyalur, Karur, Nagapattinam, Perambalur, Thanjavur, Thiruvarur, Tiruchirapalli], High rainfall [Kanyakumari], Hill [Niligiris], Northeastern [Chennai, Cuddalore, Kanchipuram, Tiruvallur, Tiruvannamalai, Vellore, Villupuram], Northwestern [Dharmapuri, Krishnagiri, Namakkal, Salem], South [Dindigul, Madurai, Pudukottai, Ramanathapuram, Sivagangai, Theni], Southern [Tirunelveli, Thoothukudi, Virudhunagar] and Western [Coimbatore, Erode, Tirupur] zones). The geographical coordinates (latitude and longitude) in the form of degree decimals of villages, where the livestock disease outbreaks occurred were collected by using online resources. The livestock disease outbreaks were mapped by using Quantum GIS software version PISA 2.10. The cluster analysis for livestock disease outbreaks was carried by using Epi Info Version 7.1, Centre for Disease Control and Prevention (CDC), Atlanta, USA.

Prevalence, Mortality, Case Fatality Rates and Bio-Climatograph

The prevalence and mortality rates per 10^3 population and case fatality rate (CFR) were calculated for each district in Tamil Nadu. For zone wise analysis, the data on various epidemiological parameters on livestock disease available for districts in the respective zones were pooled. Thus, zone wise disease data is used for calculation of zone wise prevalence, morbidity and case fatality rates. The district level monthly average weather data like minimum temperature, maximum temperature, relative humidity and rainfall were collected from online resources. The outbreaks, diagnosed cases, death cases and weather data were analyzed by preparing bio-climatograph (Bauri *et al.*, 2015).

Statistical Analysis

The descriptive analysis and one way analysis of variance (ANOVA) were calculated as per the methods described (Snedecor and Cochran, 2012) by using Statistical Analysis System software Enterprise Guide version 5.1, SAS India limited, Mumbai (SAS, 2012). The results were expressed as the Mean \pm SE (Standard Error) with significant difference at $P < 0.05$ and confidence interval at 95% level.

Results

The results of cumulative frequency of outbreaks occurred during 2002-14 (Table 1) in Tamil Nadu revealed that the highest number was reported in anthrax (109) followed by foot and mouth disease (99),

Peste des petits ruminants (45) and other diseases. The decreasing trend of livestock disease incidence was observed for all the diseases except for anthrax, BQ and FMD during 2013-14. The season wise analysis showed that more number of outbreaks reported during North east monsoon period for eight livestock diseases. Based on agroclimatic zone wise analysis, highest numbers of outbreaks were reported for anthrax, BQ, HS, Sheep and Goat pox in North eastern zone and BT, FMD and PPR in South zone. Further, 71% of livestock disease outbreaks were occurring in these two zones. The district wise analysis revealed highest number of disease outbreaks was in Madurai (80) followed by Thiruvannamalai (61) and Kancheepuram (43) districts. More number of outbreaks of BT (29), ET (3), FMD (22), PPR (11) in Madurai; BQ (13), HS (11), Sheep pox (3) in Kancheepuram and anthrax (28), Sheep pox (3) in Thiruvannamalai were reported during the period. The spatial distribution map for eight livestock disease outbreaks reported was prepared (Fig.1a). The cluster analysis results revealed that the majority of outbreaks occurred in Northeastern and South zones (Fig. 1b). Further, it showed the important disease outbreak clusters in Thiruvannamalai and Kancheepuram in Northeastern zone and Madurai in South zone.

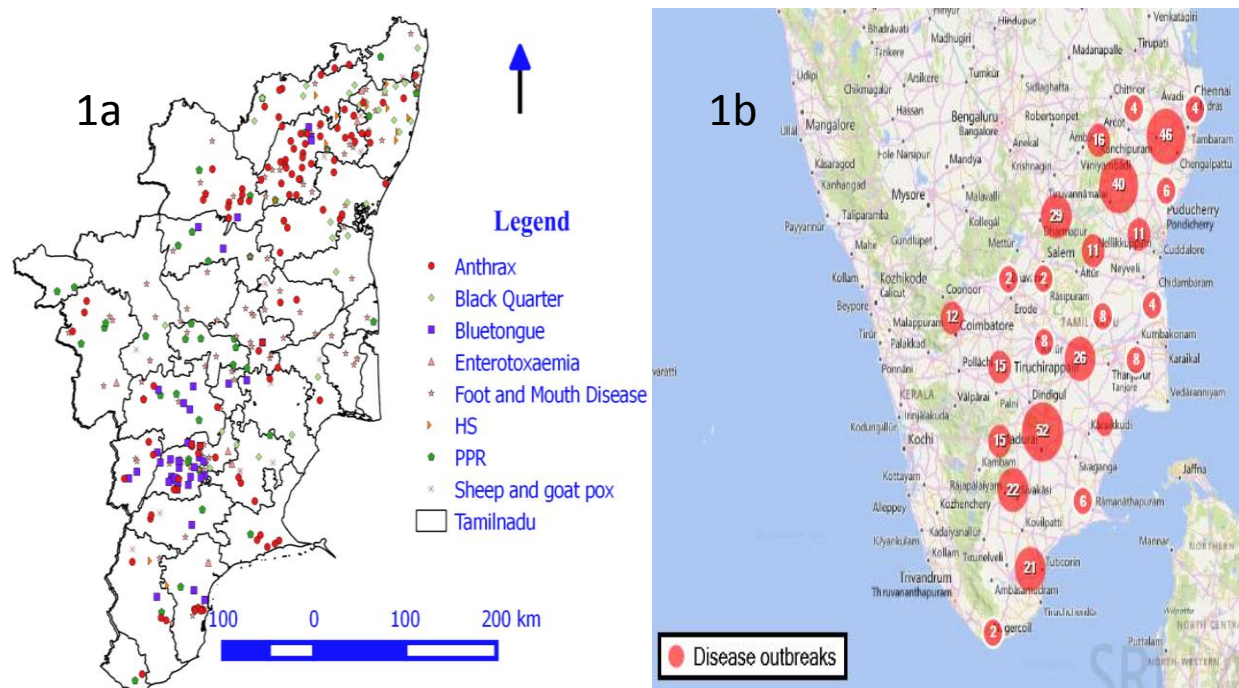


Fig.1: Spatial Distribution of Eight Livestock Disease Outbreaks Occurred in Tamil Nadu during 2002-14 (a) and Cluster Map of Livestock Disease Outbreaks (b)

Prevalence and mortality rate per 10³ population and case fatality rate (%) of livestock diseases in different agro climatic zones are presented in Table 2. The highest prevalence rate were recorded in South zone for anthrax, BQ, BT; Northeastern zone for ET, PPR; Southern zone for HS, sheep and goat pox; Cauvery delta zone for FMD. Among the eight diseases, the highest prevalence rate was observed in FMD and lowest in BQ and ET.

The mortality rate were highest for anthrax, BQ in South zone; ET, PPR in North eastern zone; FMD in Cauvery delta zone; HS, Sheep and goat pox in Southern zone districts. The mortality rate was highest in PPR and lowest in BQ and ET. CFR for ET showed significant ($P < 0.05$) difference between Western and South zone, compared to North eastern zone. The highest CFR was recorded in anthrax, HS and lowest in FMD in Tamil Nadu. The bio-climatograph for bacterial and viral diseases occurred in Tamil Nadu is depicted in Fig. 2 and 3 respectively. Among bacterial diseases, anthrax outbreaks occurred throughout the year however the more outbreaks occurred during the two rainfall peaks. The frequency of BQ outbreaks increased during onset of two monsoon period. More outbreaks of ET reported during the peak rainfall period. HS outbreaks peaked during November and also related to the peak rainfall of north east monsoon. Among viral diseases, BT occurred at the end of rainfall period and FMD during south west monsoon period. The PPR, Sheep and goat pox outbreaks reported more during the north east monsoon period indicating the relationship with the rainfall and disease outbreaks.

Table 1: Livestock disease outbreaks occurred in Tamil Nadu during 2002-14

Parameters	Anthrax	Black quarter	Bluetongue	Enterotoxaemia	Foot and Mouth Disease	Haemorrhagic Septicemia	Peste Des Petits Ruminants	Sheep and Goat Pox	Total
Year wise									
2002-03	6 (5.5)	5 (14.7)	-	4 (44.5)	18 (18.2)	2 (13.3)	-	1 (6.7)	36 (9.8)
2003-04	9 (8.3)	6 (17.7)	1 (2.3)	-	1 (1.0)	5 (33.3)	5 (11.1)	3 (20.0)	30 (8.1)
2004-05	10 (9.2)	-	31 (70.4)	1 (11.1)	4 (4.0)	4 (26.7)	5 (11.1)	3 (20.0)	58 (15.7)
2005-06	2 (1.8)	-	2 (4.6)	-	5 (5.1)	-	5 (11.1)	1 (6.7)	15 (4.0)
2006-07	2 (1.8)	-	-	-	1 (1.0)	-	-	1 (6.7)	4 (1.1)
2007-08	2 (1.8)	-	-	1 (11.1)	15 (15.1)	-	1 (2.2)	-	19 (5.1)
2008-09	1 (0.9)	1 (2.9)	-	-	2 (2.0)	-	-	-	4 (1.1)
2009-10	2 (1.8)	-	-	-	-	-	-	-	2 (0.5)
2010-11	15 (13.8)	2 (5.9)	10 (22.7)	1 (11.1)	13 (13.1)	1 (6.7)	2 (4.4)	3 (20.0)	47 (12.7)
2011-12	7 (6.4)	-	-	-	7 (7.1)	-	18 (40.0)	2 (13.2)	34 (9.2)
2012-13	19 (17.5)	10 (21.4)	-	-	7 (7.1)	-	2 (4.4)	1 (6.7)	39 (10.5)
2013-14	34 (31.2)	10 (21.4)	-	2 (22.2)	26 (26.3)	3 (20.0)	7 (15.7)	-	82 (22.2)
Total	109 (29.5)	34 (9.2)	44 (11.9)	9 (2.4)	99 (26.8)	15 (4.0)	45 (12.2)	15 (4.0)	370 (100)
Season wise									
Summer	15 (13.8)	5 (14.7)	0 (0)	1 (11.2)	2 (2.0)	0 (0)	10 (22.2)	2 (13.3)	35 (9.5)
South West Monsoon	25 (22.9)	9 (26.5)	3 (6.8)	4 (44.4)	10 (10.1)	3 (20.0)	3 (6.7)	1 (6.7)	58 (15.7)
North East Monsoon	49 (44.9)	16 (47.5)	41 (93.2)	4 (44.4)	71 (71.7)	9 (60.0)	21 (46.7)	7 (46.7)	218 (58.9)
Winter	20 (18.4)	4 (11.8)	0 (0)	0 (0)	16 (16.2)	3 (20.0)	11 (24.4)	5 (33.3)	59 (15.9)
Total	109 (29.5)	34 (9.2)	44 (11.9)	9 (2.4)	99 (26.8)	15 (4.0)	45 (12.2)	15 (4.0)	370 (100)
Zone wise									
Cauvery Delta	6 (5.5)	1 (2.9)	3 (6.8)	0 (0)	24 (24.2)	0 (0)	7 (15.6)	1 (6.7)	42 (11.4)
High Rainfall	1 (0.9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.2)	0 (0)	2 (0.5)
Hill Zone	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (2.2)	0 (0)	1 (0.3)
North Eastern Zone	59 (54.1)	29	3 (6.8)	4 (44.4)	26 (26.3)	13 (86.7)	10 (22.2)	6 (40.0)	150 (40.5)
North Western Zone	12 (11.0)	0 (0)	0 (0)	0 (0)	8 (8.1)	0 (0)	6 (13.3)	1 (6.7)	27 (7.3)
South Zone	22 (20.2)	4	31 (70.5)	4 (44.4)	31 (31.3)	0 (0)	16 (35.6)	5 (33.2)	113 (30.5)
Southern Zone	4 (3.7)	0 (0)	7 (15.9)	0 (0)	2 (2.0)	2 (13.3)	1 (2.2)	1 (6.7)	17 (4.6)
Western Zone	5 (4.6)	0 (0)	0 (0)	1 (11.2)	8 (8.1)	0 (0)	3 (6.7)	1 (6.7)	18 (4.9)
Total	109 (29.5)	34 (9.2)	44 (11.9)	9 (2.4)	99 (26.8)	15 (4.0)	45 (12.2)	15 (4.0)	370 (100)

Values in parenthesis are represented in percentage



Table 2: Zone wise Prevalence, Mortality and Case Fatality Rate of Livestock Diseases in Tamil Nadu during 2002-14

Agro-climatic zone	Anthrax	Black quarter	Bluetongue	Enterotoxaemia	Foot and Mouth Disease	Haemorrhagic Septicemia	Peste Des Petits Ruminants	Sheep and Goat Pox
Prevalence rate per 10³ population								
Cauvery Delta	0.31 ± 0.14	0.04	0.03 ± 0.001	-	14.78 ± 7.88	-	0.43 ± 0.0	-
High Rainfall	0.47 ± 0.0	-	-	-	-	-	0.66 ± 0.0	-
Hill Zone	-	-	-	-	-	-	1.64 ± 0.0	-
North Eastern Zone	0.32 ± 0.19	0.05 ± 0.02	0.09 ± 0.0	0.08 ± 0.01	0.83 ± 0.41	0.06 ± 0.005	5.81 ± 0.56	0.17 ± 0.0
North Western Zone	0.21 ± 0.06	-	-	-	0.55 ± 0.20	-	0.81 ± 0.08	0.11 ± 0.0
South Zone	0.98 ± 0.47	0.06 ± 0.03	1.79 ± 0.58	0.04 ± 0.008	1.58 ± 0.65	-	0.02 ± 0.0	0.04 ± 0.0
Southern Zone	0.10 ± 0.01	-	1.79 ± 0.78	-	0.01 ± 0.001	0.11 ± 0.0	0.63 ± 0.19	0.23 ± 0.13
Western Zone	0.87 ± 0.0	-	-	0.01 ± 0.0	0.75 ± 0.40	-	0.11 ± 0.0	0.02 ± 0.0
Total	0.50 ± 0.15	0.05 ± 0.01	1.05 ± 0.62	0.05 ± 0.014	4.37 ± 2.40	0.07 ± 0.04	2.49 ± 0.20	0.15 ± 0.06
CI at 95% level	0.21 - 0.79	0.03 - 0.06	0.16 - 2.26	0.02 - 0.07	0.33 - 9.07	0.008 - 0.15	2.09 - 2.88	0.03 - 0.27
Mortality rate per 10³ population								
Cauvery Delta	0.28 ± 0.14	0.04	0.007 ± 0.004	-	0.42 ± 0.23	-	0.01 ± 0.0	-
High Rainfall	0.47 ± 0.0	-	-	-	-	-	0.25 ± 0.0	-
Hill Zone	-	-	-	-	-	-	0.74 ± 0.0	-
North Eastern Zone	0.32 ± 0.19	0.04 ± 0.01	0.006 ± 0.0	0.05 ± 0.007	0.06 ± 0.02	0.05 ± 0.005	5.35 ± 0.59	0.08 ± 0.0
North Western Zone	0.21 ± 0.07	-	-	-	0.04 ± 0.008	-	0.01 ± 0.002	0.04 ± 0.0
South Zone	0.94 ± 0.46	0.04 ± 0.02	0.70 ± 0.06	0.04 ± 0.01	0.19 ± 0.05	-	0.01 ± 0.0	0.01 ± 0.0
Southern Zone	0.87 ± 0.0	-	0.08 ± 0.008	-	0.001 ± 0.0004	0.11 ± 0.0	0.07 ± 0.006	0.19 ± 0.13
Western Zone	0.49 ± 0.14	-	-	0.11 ± 0.0	0.10 ± 0.04	-	0.007 ± 0.0	0.02 ± 0.0
Total	0.49 ± 0.14	0.04 ± 0.01	0.23 ± 0.02	0.04 ± 0.008	0.17 ± 0.06	0.07 ± 0.03	1.97 ± 0.18	0.11 ± 0.05
CI at 95% level	0.21 - 0.76	0.02 - 0.06	0.19 - 0.27	0.02 - 0.05	0.05 - 0.28	0.01 - 0.13	1.62 - 2.32	0.01 - 0.21
Case Fatality rate (%)								
Cauvery Delta	92.82 ± 6.01	85.71	20.63 ± 1.57	-	7.07 ± 2.25	-	2.17 ± 0.0	-
High Rainfall	100.00 ± 0.0	-	-	-	-	-	37.84 ± 0.0	-
Hill Zone	-	-	-	-	-	-	44.93 ± 0.0	-
North Eastern Zone	100.00 ± 0.0	87.67 ± 7.06	6.82 ± 0.0	66.26 ± 4.19 ^c	10.54 ± 2.93	88.77 ± 5.90	52.30 ± 18.38	47.62 ± 0.0
North Western Zone	100.00 ± 0.0	-	-	-	19.45 ± 11.79	-	0.75 ± 0.07	33.33 ± 0.0
South Zone	97.43 ± 2.04	72.86 ± 3.15	26.62 ± 1.41	94.44 ± 5.55 ^{ab}	14.96 ± 5.03	-	66.67 ± 0.0	33.33 ± 0.0
Southern Zone	87.50 ± 12.50	-	14.95 ± 1.05	-	6.25 ± 0.62	100.00 ± 0.0	9.03 ± 0.74	78.05 ± 17.77
Western Zone	100.00 ± 0.0	-	-	100.00 ± 0.0 ^a	12.40 ± 3.81	-	6.25 ± 0.0	66.67 ± 0.0
Total	96.71 ± 1.69	82.52 ± 4.53	18.75 ± 0.57	84.28 ± 7.74	11.79 ± 2.17	91.57 ± 5.03	31.35 ± 9.04	59.30 ± 10.34

^{a, b, c} Mean with same superscript with in the column do not differ (P>0.05) significantly; CI - Confidence Interval

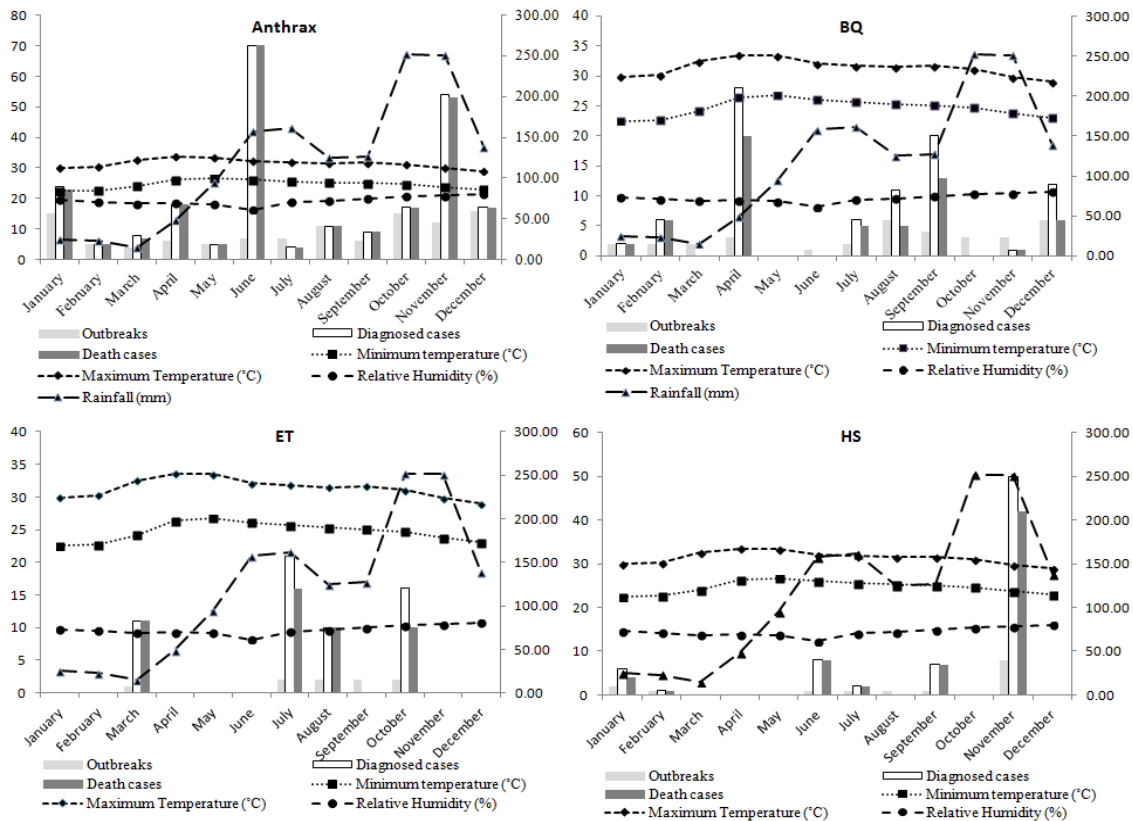


Fig.2: Bio-climatograph of Bacterial Diseases Occurred in Tamil Nadu State During 2002-14

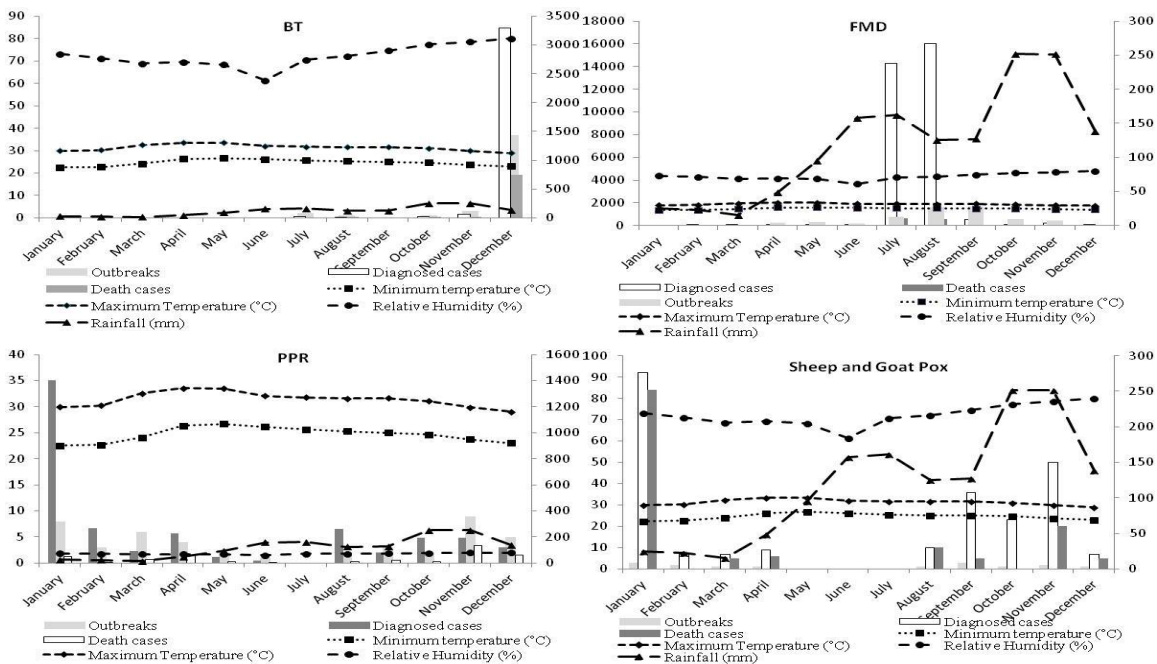


Fig.3: Bio-climatograph of Viral Diseases Occurred in Tamil Nadu State During 2002-14

Discussion

Among the diseases studies, more number of outbreaks was reported for anthrax. In a 15 years (1991-2006) study of anthrax outbreaks, 619 outbreaks were reported indicating the importance of anthrax in Tamil Nadu (Gunaseelan *et al.*, 2011). However, in the present study, 109 anthrax outbreaks was reported for 12 years (2002-2014) and might be less due to effective vaccination and preventive measures undertaken over the period. In a study in Lahore, Pakistan reported that FMD, HS and gastro-intestinal diseases were the main cause of economic losses (Khan *et al.*, 1994) and concurred with the present study. A total of 2,463 cattle and buffaloes were affected with FMD between 2002 and 2008 with death cases in 394 animals were reported (Shamsudeen *et al.*, 2013) and concurred with the present study. Across the years, decreasing trend in outbreaks of diseases was observed except during 2013-14, where increase in anthrax and FMD outbreaks reported. HS outbreaks occurred during monsoon and post monsoon seasons in southern India (Krishnamoorthy *et al.*, 2014) and North-East monsoon in Tamil Nadu (Krishnamoorthy *et al.*, 2016) and were in agreement with the present study. Krishnamoorthy *et al.* (2015) also reported highest occurrence of HS outbreaks during South-West monsoon period in Assam state and corroborated with this study. It implies during monsoon period, highest frequency of livestock diseases are reported than other seasons of the year. Among the districts, anthrax outbreaks reported was high in Thiruvannamalai and was in agreement with the previous report (Gunaseelan *et al.*, 2011). Based on cluster analysis, the outbreaks reported were high in Madurai, Kancheepuram and Thiruvannamalai and hence more attention is warranted in these districts especially by following appropriate vaccination strategies. Moreover, the vaccination is to be carried out before the onset of the monsoon for effective protection against major diseases. The CFR for HS reported was 51.4% in Assam (Krishnamoorthy *et al.*, 2015) and 89.47% in Tamil Nadu (Krishnamoorthy *et al.*, 2014) and was in agreement with the present study. The CFR for FMD in cattle reported in Erode district of Tamil Nadu was 16% (Shamsudeen *et al.*, 2014) and corroborated with the present study. In the present study, high CFR for anthrax was observed, however low CFR was reported in Bangladesh (Mondal and Yamage, 2014) which may be due to geographical and climatic variations. In a study on BT outbreaks in northwest agroclimatic zone of Tamil Nadu, the CFR was 53.82% (Selvaraju, 2014) and was in agreement with the present study. Based on bio-climatograph, there was relationship between the livestock disease outbreaks and rainfall or monsoon periods. Anthrax outbreaks reported throughout the year but peak outbreaks coincides with the peak rainfall and concurred with the previous report (Gunaseelan *et al.*, 2011). ET outbreaks peaked during July and October months and correspond to the peaks rainfall periods. HS outbreaks peaked during the peak rainfall during November month and corroborated with the previous study (Mondal and Yamage, 2014). BT occurred during the month of November and December in Erode district when heavy rainfall conditions make congenial environment for the multiplication of vectors *Culicoides* sp. (Yasothai, 2013)

and concurred with the present study. FMD outbreaks occurred throughout the year however increased frequency was reported during the monsoon period (July-October). The FMD occurred from August to February of the calendar year in Erode district of Tamil Nadu (Shamsudeen *et al.*, 2013) and concurred with the present study. Increased frequency of PPR, sheep and goat pox outbreaks were observed during September to January and coincides with peak and end of rainfall period. The above findings from this study concurred with previous report for FMD, HS and PPR diseases in which the diseases mostly occurred through the monsoon seasons in Bangladesh (Mondal and Yamage, 2014).

The decreasing trend of disease outbreaks observed in the study, might be due to vaccination programmes under various Government of India sponsored schemes like Assistance to States for Control of Animal Diseases (ASCAD), Foot and Mouth Disease-Control Programme (FMD-CP) and National Control Programme on Pesti des petits ruminants (NCP-PPR). Despite the vaccination programmes, the disease incidence is reported high in North-east and South zones and may be due to low vaccination coverage, low vaccine efficacy and unrestricted movement of animals, etc. As a part of vaccination campaigns, state Governments should assess the vaccine efficacy, develop a strategy to improve the vaccination coverage and conduct sero-surveillance to determine the coverage and duration of immunity for these livestock diseases. The findings in this study is based the diseases reported, however there are likely biases in the reporting system. We assumed these possible variables remained relatively constant during the study period in Tamil Nadu and analyzed the data.

Conclusions and Recommendation

The present study provides the baseline information about the spatial distribution of anthrax, BQ, BT, ET, FMD, HS, PPR, Sheep and Goat pox diseases in Tamilnadu state for the period 2002-14. The disease outbreak was high in Northeastern and South zone districts of Tamil Nadu and more specifically in north east monsoon period. Thus, appropriate preventive vaccinations against BT, FMD, PPR in Madurai, BQ, HS in Kancheepuram and anthrax, sheep pox in Thiruvannamalai districts has to be initiated especially before the onset of monsoon period, to mitigate the livestock diseases in Tamil Nadu state. There is also need for laboratory (serological and molecular) confirmation of clinically diagnosed cases for various livestock diseases to have better confirmation of livestock diseases. Further, there is need for identification of disease free zones by effectively doing preventive vaccinations in this zone for these diseases. By increasing the area of disease free zones in Tamil Nadu state will benefit the various stake holders in the livestock value chain and also boost the economy of the country.

Acknowledgement

The authors thank the Indian Council of Agricultural Research, New Delhi for providing the support for doing this research work under Institute Research Project. The authors are thankful to the Department of Animal Husbandry and Veterinary Services, Government of Tamil Nadu and express gratitude to the staff members of Central Referral Laboratory, Chennai and all field Veterinarians for their help in the disease outbreak reporting process.

References

1. Bauri RK, Chandra D, Lalrinkima H, Raina OK, Tigga MN and Kaur N. 2015. Epidemiological studies on some trematode parasites of ruminants in the snail intermediate hosts in three districts of Uttar Pradesh, Jabalpur and Ranchi. *Indian Journal of Animal Sciences*, 85: 941-946.
2. BAHS. 2014. Basic Animal Husbandry Statistics-2014. AHS series 15. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India, New Delhi.
3. Gunaseelan L, Rishikesavan R, Adarsh T, Baskar R, Hamilton E and Kaneene J.B. 2011. Temporal and geographical distribution of animal anthrax in Tamil Nadu state, India. *Tamilnadu Journal of Veterinary and Animal Sciences*, 7: 277-284.
4. Khan MA, Yamin M, Khan MS and Khan AG. 1994. Epidemiological and economical based ranking order of buffalo and cattle diseases through Active Disease Surveillance system. Proc. 8th International Congress on Animal Hygiene, 12-16 September 1994, Minnesota, USA. pp. 147.
5. Krishnamoorthy P, Govindaraj G, Sri Devi R, Shome BR and Rahman H. 2014. Epidemiological analysis of Haemorrhagic septicemia and Foot and Mouth disease occurred in Southern India. Proc. 2nd International Animal and Dairy Science conference, 15-17 September 2014, Omics group, Hyderabad. pp. 48.
6. Krishnamoorthy P, Das SK, Rajshree V, Govindaraj G, Shome BR and Rahman H. 2015. Haemorrhagic septicemia and Foot and mouth disease occurrence in Assam: an epidemiological analysis. Compendium of National symposium on Challenges and advances in Disease Diagnosis of Livestock, Poultry and Fish: Redefining the role of Veterinary Pathologists, 3-5 December 2015. Gannavaram, Andhra Pradesh. pp. 44-45.
7. Krishnamoorthy P, Govindaraj G, Rajshree V, Shome BR and Rahman H. 2016. Spatio-temporal epidemiological analysis of livestock diseases: A case of Tamilnadu. Compendium of Global symposium on Animal Health: Newer technologies and their applications, 12-14 February 2016. Guwahati, Assam. pp. 128-129.
8. Martin SW, Meek AH and Willeberg P. 1994. Veterinary Epidemiology: Principles and Methods, Iowa State University Press, Ames, Iowa.
9. Mondal PS and Yamage M. 2014. A retrospective study on the epidemiology of Anthrax, Foot and Mouth disease, Haemorrhagic Septicaemia, Peste des Petits Ruminants and Rabies in Bangladesh, 2010-2012. *Plos One*, 9(8): e104435.
10. Perry BD, Gleeson LJ, Khounsey S, Bounma P and Blacksell SD. 2002. The dynamics and impact of foot and mouth disease in smallholder farming systems in South-East Asia: a case study in Laos. *Review of Scientific and Technical OIE*, 21: 663-673.
11. Rosenberger G. 1979. Clinical Examination of Cattle. Second edition, Verlag Paul Parey Publications, Germany.
12. Samad MA. 2000. Veterinary Practitioner's Guide. First edition. LEP publications. No. 07. Bangladesh Agricultural University Campus, Mymensingh, Bangladesh.
13. SAS. 2012. Statistical Analysis System. Software Version 9.3, SAS India Limited, India
14. Selvaraju G. 2014. Epidemiological measures of disease occurrence in Bluetongue. *International Journal of Scientific Research*, 3: 74-76.

15. Shamsudeen P, Yasothai R and Gopalakrishna Murthy TR. 2013. An epidemiological study on Foot and Mouth disease outbreak in cattle of Erode district of Tamil Nadu. *Tamilnadu Journal of Veterinary and Animal Sciences*, 9: 221-226.
16. Snedecor GW and Cochran WG. 1980. *Statistical Methods*. 7th Edn. Ames, The Iowa State University Press, Iowa, USA.
17. Yasothai R. 2013. A report on outbreak of Bluetongue in Erode district of Tamil Nadu. *International Journal of Science and Environmental Technology*, 2: 646-648.