

# Spatial and Temporal Epidemiological Analysis of Livestock Diseases in Maharashtra State

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## Abstract

*In the present study, spatio-temporal analysis of livestock diseases in Maharashtra was undertaken. Time series data (2005–2016) on outbreaks, diagnosed cases, death cases, districts were collected and analyzed for epidemiological parameters likes cumulative outbreaks, diagnosed cases, death cases, spatial distribution, prevalence rate, mortality rate and case fatality rates. Cumulative outbreaks during the period was highest for Black Quarter (BQ) (203) followed by Haemorrhagic Septicemia (HS) (176), Pesti des petits ruminants (PPR) (137), Swine Fever (SF) (36), Sheep and Goat (SG) Pox (33), Foot and Mouth disease (FMD) (6), Anthrax (SG) (18), Enterotoxaemia (ET) (17) and Anthrax (Bovines) (7). The spatial distribution analysis revealed highest cumulative outbreaks were in Ahmednagar (106), Latur (85) and Nashik (59) districts. Agroclimatic zone wise analysis revealed that more outbreaks were reported from Central Maharashtra Plateau zone (37.2%), Western Maharashtra Plain zone (24.1%) and Western Ghat zone (12.9%). The prevalence rate per 10<sup>3</sup> population revealed highest in SF (29.24), followed by PPR (3.39), Pox (0.34), FMD (0.16), HS (0.11), Anthrax (SG) (0.09), BQ (0.06), Anthrax (Bovines) (0.04) and ET (0.04). The case fatality rate was highest for SF (68.1%), Anthrax (SG) (64.5%) and BQ (62.8%), as observed. Based on epidemiological analysis, it may be concluded that BQ, HS, PPR and SF were the important livestock diseases in Maharashtra, its occurrence were high in Central Maharashtra Plateau, Western Maharashtra plain and Western Ghat and in Ahmednagar, Latur, Pune and Nashik districts. Thus, appropriate preventive measures need to be undertaken in the identified areas to mitigate the livestock diseases in Maharashtra state.*

**Keywords:** Spatial, temporal analysis, livestock diseases, Maharashtra

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## INTRODUCTION

Livestock diseases of infectious nature are critically important in livestock farming systems, since disease outbreaks reduce the growth and productivity of animals. Epidemiological analysis of livestock diseases will help in proper planning, execution and monitoring of livestock disease control programmes and preventive measures. The livestock diseases are important since it causes great economic loss to the farmers and affects the economy in India. Maharashtra, a state in western region India, comprises of 36 districts with total livestock population of 32.49 million consisting of 15.48, 5.59, 2.58 and 8.43 million of cattle, buffalo, sheep and goat, respectively as per 19th livestock census 2012 [1]. Maharashtra state continues to experience

disease outbreaks like Anthrax (Bovines), Black quarter (BQ), Foot and Mouth Disease (FMD), Haemorrhagic Septicemia (HS) in large ruminants (cattle and buffaloes) and Anthrax (SG), Enterotoxaemia (ET), Peste des petits ruminants (PPR), Sheep and Goat (SG) pox in small ruminants (sheep and goats) and Swine Fever (SF) in pigs. 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 [2]. The objective of an epidemiological study is to identify the districts, zones, and species prone for disease outbreaks and that need to be taken into consideration in the development of effective preventive and control measures. The spatial and temporal epidemiological analysis of

livestock diseases occurred in Tamil Nadu has been carried previously and identified the important zones and period for implementing the preventive measures as reported [3]. Epidemiological analysis of livestock diseases outbreaks in Maharashtra state is not available and very few literatures are available for other states in India. Hence, the present study on spatial and temporal epidemiological analysis of eight livestock diseases namely four bacterial and four viral diseases for Maharashtra state reported during April 2005 to March 2016 was undertaken.

## MATERIALS AND METHODS

Maharashtra State is situated at the western region of India, second most populous state and third largest state by area. It has an area of 3,07,713 sq. km (118,809 sq. miles) and is bordered by Arabian sea to the west and the Indian states of Karnataka, Telangana, Goa, Gujarat, Chhattisgarh, Madhya Pradesh and Dadar Nagar Haveli. The spatio-temporal data was collected from Department of Animal Husbandry, Government of Maharashtra. In this study, an outbreak is considered when animals showed clinical signs or lesions characteristic of Anthrax, BQ, ET, FMD, HS, PPR, SG Pox or SF but in some instances, there was supportive laboratory confirmation as reported in earlier studies [4, 5]. The secondary data on eight livestock diseases namely, outbreaks, diagnosed cases, death cases, year and districts were collected for the period April 2005 to March 2016 as prescribed in the earlier studies [3, 6]. The district level livestock population was collected from 19th Livestock Census 2012 report [1]. The year wise analysis of the livestock disease outbreaks reported was carried to assess the trend pattern of diseases. Based on soil characteristics, rainfall distribution, irrigation pattern, cropping pattern and other ecological and social characteristics, the Maharashtra State has been classified into nine agroclimatic zones namely South Konkan Coastal zone (Ratnagiri, Sindhudurg, Palghar), North Konkan Coastal zone (Thane, Raigad, Mumbai city, Mumbai suburban), Western Ghat zone (Nashik, Dhule, Nandurbar), Sub Mountain zone (Kolhapur, Satara), Western Maharashtra plain zone (Pune, Ahmednagar), Western Maharashtra Scarcity zone (Solapur, Sangli,

Beed), Central Maharashtra Plateau Zone (Aurangabad, Jalna, Parbhani, Buldhana, Nanded, Hingoli, Akola, Osmanabad, Amaravati, Jalgaon, Latur), Central Vidarbha zone (Yavatmal, Wardha, Washim) and Eastern Vidarbha zone (Bhandara, Gadchiroli, Chandrapur, Nagpur, Gondia). The zone wise analysis of outbreaks, diagnosed cases and death cases was carried out. The district wise analysis of outbreaks, diagnosed and death cases for bacterial and viral diseases separately was carried out. The prevalence and mortality rates per 10<sup>3</sup> population and case fatality rate (CFR) were calculated for different zones in Maharashtra. 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 rate, morbidity rate and CFR which were calculated as reported previously [3].

## RESULTS AND DISCUSSION

The results of cumulative frequency of outbreaks occurred during 2005–16 in Maharashtra is given in Table 1. Year wise analysis during the period revealed that the cumulative number of outbreaks was highest in black quarter (BQ) (203) followed by Haemorrhagic septicaemia (HS) (176), Pesti des petits ruminants (PPR) (137), Swine fever (SF) (36), Sheep and Goat (SG) Pox (33), Foot and Mouth disease (FMD) [6], Anthrax (sheep and Goat) (18), Enterotoxaemia (ET) (17) and Anthrax (bovine) (7). Among the diseases studies, more number of outbreaks was reported for BQ in Maharashtra and concurred with the previous report [7]. In the present study, livestock disease outbreaks in Maharashtra showed decreasing trend over the past eleven years period, except for PPR. In a study, anthrax outbreaks reported during 1991–2005 was 619 outbreaks, which indicated the importance of anthrax in Tamil Nadu and also reported endemic nature of Anthrax in Maharashtra [8]. However, in the present study, 25 Anthrax outbreaks were reported during the study period 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 and

concurrent with the present study [9]. The cumulative diagnosed cases reported were highest in PPR (25,200) followed by SF (6,084), HS (1,794), SG Pox (1,340), FMD (1,193), BQ (1,006), Anthrax (SG) (304), Anthrax (Bovines) (227) and ET (123). The cumulative death cases reported were highest in PPR (6,204) followed by SF (4147), HS (857), BQ (632), SG Pox (350), Anthrax (SG) (196), ET (70), Anthrax (Bovines) (58) and FMD (44). The number of diagnosed cases was 1,193, with 44 death cases during the period for FMD, however, previous report indicated a little higher number of diagnosed cases (2,463) and death cases (394) in cattle and buffaloes with FMD during 2002–08 [10]. This indicated that the BQ, FMD, HS in cattle, PPR in sheep and goats and SF in pigs are the most important and devastating diseases of animals in Maharashtra state.

Based on the district wise analysis, the BQ, FMD, PPR outbreaks were highest in Ahmednagar, Anthrax (SG), ET in Pune, Anthrax (Bovines) in Raigad, HS in Latur, SG Pox in Sangli and SF in Chandrapur districts. The details of bacterial and viral diseases outbreaks reported in various districts of Maharashtra are presented in the Figure 1A and 1B, respectively. The highest number of cumulative diagnosed cases was reported in Pune (19,324), Nashik (2,556) and Ahmednagar (2,354) and death cases in Pune (4,975) and Nashik (1,026). Based on agroclimatic zone wise analysis, highest number of outbreaks were reported for Anthrax (Bovines) in North Konkan Coastal zone, Anthrax (SG), ET, FMD, PPR in Western Maharashtra Plain zone, BQ, HS in Central Maharashtra Plateau zone, SG pox in Western Maharashtra Scarcity zone, SF in Western Ghat and Eastern Vidarbha zones. The cumulative outbreaks was highest in Central Maharashtra Plateau zone (242), followed by Western Maharashtra Plain zone (157) and Western Ghat zone (84). Further, 74% of livestock disease outbreaks were occurred in these three zones only.

Prevalence and mortality rate per  $10^3$  population and case fatality rate (%) of livestock diseases in different agro climatic zones are presented in Table 2. The prevalence

rate per  $10^3$  population revealed highest in SF (29.24), followed by PPR (3.39), SG Pox (0.34), FMD (0.16), HS (0.11), Anthrax (SG) (0.09), BQ (0.06), Anthrax (Bovines) (0.04) and ET (0.04). This indicated the importance of FMD, HS and BQ in Bovines, PPR in sheep and goats, and SF in pigs. The mortality rate per  $10^3$  population was highest in SF (19.93), followed by PPR (0.83), SG Pox (0.09), Anthrax (SG) (0.06), HS (0.05), BQ (0.04), ET (0.02), Anthrax (Bovines) (0.01) and FMD (0.006). The prevalence and mortality rates revealed variation between the diseases indicating the level of importance and concurrent with the previous report [3]. The case fatality rate was highest for SF (68.1%), Anthrax (sheep and goat) (64.5%), BQ (62.8%), ET (56.9) and HS (47.8%), as observed. This attributed to the economic loss of the animals due to the disease outbreaks in Maharashtra state. In the present study, high CFR for Anthrax (SG) (64.5%) and low CFR for Anthrax (Bovines) was observed and concurrent with the previous report from Bangladesh [11]. The CFR for FMD in cattle reported in Erode district of Tamil Nadu was 16% [12] and found to be less when compared to 3.7% in the present study. The CFR for HS reported was 51.4% in Assam and 89.47% in Tamil Nadu and was less in the present study [12, 13]. 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 outbreaks are reported high in Central Maharashtra Plateau, Western Maharashtra Plain and Western Ghat 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 Animal Husbandry Departments should assess the vaccine efficacy, develop strategies 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 are based on the diseases reported, however there are

likely biases in the reporting system and the study assumed that these possible variables

remained relatively constant during the study period in Maharashtra and analyzed the data.

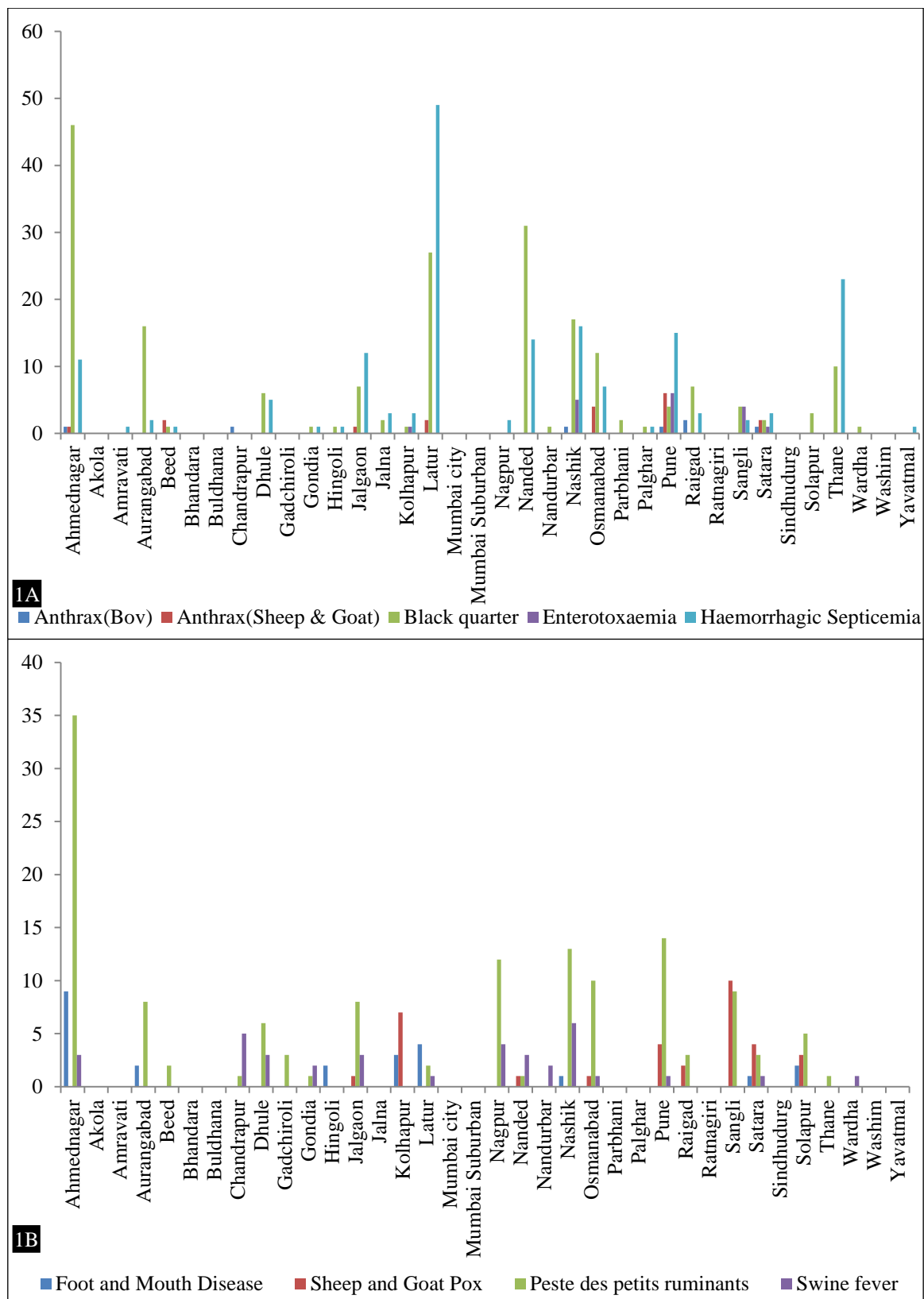


Fig. 1: District-wise Livestock Disease Outbreaks Occurred in Maharashtra State during 2005–16: A) Bacterial Diseases and B) Viral Diseases.

**Table 1: Livestock Disease Outbreaks Occurred in Maharashtra during 2005–16.**

Parameters	Anthrax (Bovines)	Anthrax (Sheep and Goat)	Black Quarter	Enterotoxaemia	Foot and Mouth Disease	Haemorrhagic Septicemia	Peste Des Petits Ruminants	Sheep and Goat Pox	Swine Fever	Total
<b>Year wise</b>										
2005–06	2 (28.6)	2 (11.1)	39 (19.2)	2 (11.8)	9 (37.5)	44 (25.0)	28 (20.4)	2 (6.1)	0 (0.0)	<b>128 (19.7)</b>
2006–07	1 (14.3)	1 (5.6)	20 (9.9)	4 (23.5)	5 (20.8)	24 (13.6)	10 (7.3)	11 (33.3)	10 (27.8)	<b>86 (13.2)</b>
2007–08	2 (28.6)	4 (22.2)	37 (18.2)	4 (23.5)	2 (8.3)	26 (14.8)	5 (3.7)	9 (27.3)	5 (13.9)	<b>94 (14.4)</b>
2008–09	1 (14.3)	3 (16.6)	31 (15.3)	1 (5.9)	0 (0.0)	30 (17.0)	11 (8.0)	0 (0.0)	3 (8.3)	<b>80 (12.3)</b>
2009–10	0 (0.0)	2 (11.1)	24 (11.9)	1 (5.9)	0 (0.0)	11 (6.2)	16 (11.7)	1 (3.0)	8 (22.2)	<b>63 (9.7)</b>
2010–11	1 (14.3)	1 (5.6)	22 (10.8)	0 (0.0)	0 (0.0)	13 (7.4)	9 (6.6)	3 (9.1)	2 (5.6)	<b>51 (7.8)</b>
2011–12	0 (0.0)	5 (27.8)	12 (5.9)	1 (5.9)	0 (0.0)	6 (3.4)	4 (2.9)	5 (15.1)	5 (13.9)	<b>38 (5.8)</b>
2012–13	0 (0.0)	0 (0.0)	10 (4.9)	1 (5.9)	0 (0.0)	8 (4.6)	5 (3.7)	0 (0.0)	1 (2.8)	<b>25 (3.8)</b>
2013–14	0 (0.0)	0 (0.0)	6 (2.9)	3 (17.6)	8 (33.4)	5 (2.8)	7 (5.1)	0 (0.0)	2 (5.6)	<b>31 (4.8)</b>
2014–15	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.6)	21 (15.3)	2 (6.1)	0 (0.0)	<b>24 (3.7)</b>
2015–16	0 (0.0)	0 (0.0)	2 (1.0)	0 (0.0)	0 (0.0)	8 (4.6)	21 (15.3)	0 (0.0)	0 (0.0)	<b>31 (4.8)</b>
<b>Total</b>	<b>7 (1.1)</b>	<b>18 (2.8)</b>	<b>203 (31.2)</b>	<b>17 (2.6)</b>	<b>24 (3.7)</b>	<b>176 (27.0)</b>	<b>137 (21.0)</b>	<b>33 (5.1)</b>	<b>36 (5.5)</b>	<b>651 (100.0)</b>
<b>Zone wise</b>										
South Konkan Coastal	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	0 (0.0)	1 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	<b>2 (0.3)</b>
North Konkan Coastal	2 (28.6)	0 (0.0)	17 (8.4)	0 (0.0)	0 (0.0)	26 (14.8)	4 (2.9)	0 (0.0)	0 (0.0)	<b>49 (7.5)</b>
Western Ghat	1 (14.3)	0 (0.0)	24 (11.8)	5 (29.4)	1 (4.2)	21 (11.9)	19 (13.9)	2 (6.1)	11 (30.6)	<b>84 (12.9)</b>
Sub Mountain	1 (14.3)	2 (11.1)	3 (1.5)	2 (11.8)	4 (16.7)	6 (3.4)	3 (2.2)	11 (33.3)	1 (2.8)	<b>33 (5.1)</b>
Western Maharashtra plain	2 (28.6)	7 (38.9)	50 (24.6)	6 (35.3)	9 (37.5)	26 (14.8)	49 (35.8)	4 (12.1)	4 (11.1)	<b>157 (24.1)</b>
Western Maharashtra Scarcity	0 (0.0)	2 (11.1)	8 (3.9)	4 (23.5)	2 (8.3)	3 (1.7)	16 (11.7)	13 (39.4)	0 (0.0)	<b>48 (7.3)</b>
Central Maharashtra Plateau	0 (0.0)	7 (38.9)	98 (48.3)	0 (0.0)	8 (33.3)	89 (50.6)	29 (21.1)	3 (9.1)	8 (22.2)	<b>242 (37.2)</b>
Central Vidarbha	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	0 (0.0)	1 (0.6)	0 (0.0)	0 (0.0)	1 (2.8)	<b>3 (0.5)</b>
Eastern Vidarbha	1 (14.3)	0 (0.0)	1 (0.5)	0 (0.0)	0 (0.0)	3 (1.7)	17 (12.4)	0 (0.0)	11 (30.6)	<b>33 (5.1)</b>
<b>Total</b>	<b>7 (1.1)</b>	<b>18 (2.8)</b>	<b>203 (31.2)</b>	<b>17 (2.6)</b>	<b>24 (3.7)</b>	<b>176 (27.0)</b>	<b>137 (21.0)</b>	<b>33 (5.1)</b>	<b>36 (5.5)</b>	<b>651 (100.0)</b>

Values in the Parenthesis are represented in Percentage.

**Table 2: Zone wise Prevalence and Mortality Rate per 10<sup>3</sup> Population, and Case Fatality Rate of Livestock Diseases in Maharashtra State.**

Agro-Climatic Zones	Anthrax (Bovines)	Anthrax (Sheep and Goat)	Black Quarter	Enterotoxaemia	Foot and Mouth Disease	Haemorrhagic Septicemia	Peste Des Petits Ruminants	Sheep and Goat Pox	Swine Fever
<b>Prevalence Rate per 10<sup>3</sup> Population</b>									
South Konkan Coastal	0	0	0.0167	0	0	0.0467	0	0	0
North Konkan Coastal	0.0171	0	0.1179	0	0	0.2662	0.8095	0.261	0
Western Ghat	0.0008	0	0.118	0.0199	0.1077	0.0831	1.3032	0	36.28
Sub Mountain	0.0027	0.0349	0.0074	0.0393	0.2762	0.0624	0.5792	0.5489	10.335
Western Maharashtra plain	0.0052	0.027	0.0573	0.0344	0.2014	0.167	10.351	0.2376	55.87
Western Maharashtra Scarcity	0	0.0572	0.0458	0.0975	0.1958	0.0308	0.6629	0.3194	0
Central Maharashtra Plateau	0	0.2791	0.0685	0	0.0298	0.1124	2.3566	0.2814	8.8561
Central Vidarbha	0	0	0.0085	0	0	0.0269	0	0	24.555
Eastern Vidarbha	0.3474	0	0.0352	0	0	0.2667	1.1164	0	27.808
<b>Total</b>	<b>0.0407</b>	<b>0.0848</b>	<b>0.0617</b>	<b>0.0413</b>	<b>0.1631</b>	<b>0.118</b>	<b>3.3945</b>	<b>0.3442</b>	<b>29.244</b>
<b>Mortality Rate per 10<sup>3</sup> Population</b>									
South Konkan Coastal	0	0	0.0151	0	0	0.0327	0	0	0
North Konkan Coastal	0.0171	0	0.0944	0	0	0.1887	0.2288	0	0
Western Ghat	0.0008	0	0.0864	0.0125	0.0104	0.0509	0.3211	0	14.762
Sub Mountain	0.0027	0.0471	0.0056	0.0155	0.0142	0.026	0.0907	0.156	8.3127
Western Maharashtra plain	0.0041	0.0211	0.0366	0.0172	0.0036	0.0562	2.4546	0.0444	53.697
Western Maharashtra Scarcity	0	0.0522	0.0226	0.0685	0.0017	0.0121	0.2313	0.1331	0
Central Maharashtra Plateau	0	0.1442	0.0357	0	0	0.0729	0.621	0.0056	4.9612
Central Vidarbha	0	0	0.0057	0	0	0.0049	0	0	19.573
Eastern Vidarbha	0.0661	0	0.0282	0	0	0.0419	0.3295	0	25.093
<b>Total</b>	<b>0.0104</b>	<b>0.0547</b>	<b>0.0388</b>	<b>0.0235</b>	<b>0.006</b>	<b>0.0564</b>	<b>0.8357</b>	<b>0.0899</b>	<b>19.933</b>
<b>Case Fatality Rate (%)</b>									
South Konkan Coastal	0.0	0.0	90.0	0.0	0.0	70.0	0.0	0.0	0.0
North Konkan Coastal	100.0	0.0	80.0	0.0	0.0	70.9	28.3	0.0	0.0
Western Ghat	100.0	0.0	73.2	63.2	9.6	61.3	24.6	0.0	40.7
Sub Mountain	100.0	74.1	75.0	39.4	5.1	41.6	15.7	28.4	80.4

Western Maharashtra plain	78.6	78.0	63.9	50.0	1.8	33.6	23.7	18.7	96.1
Western Maharashtra Scarcity	0.0	91.3	49.2	70.2	0.9	39.2	34.9	41.7	0.0
Central Maharashtra Plateau	0.0	51.7	52.1	0.0	0.0	64.9	26.3	2.0	56.0
Central Vidarbha	0.0	0.0	66.7	0.0	0.0	18.2	0.0	0.0	79.7
Eastern Vidarbha	19.0	0.0	80.0	0.0	0.0	15.7	29.5	0.0	90.2
<b>Total</b>	<b>25.6</b>	<b>64.5</b>	<b>62.8</b>	<b>56.9</b>	<b>3.7</b>	<b>47.8</b>	<b>24.6</b>	<b>26.1</b>	<b>68.2</b>

## CONCLUSION

The present study provides the baseline information about the spatial distribution of Anthrax in bovines, sheep and goats, BQ, ET, FMD, HS, PPR, SG Pox and SF diseases in Maharashtra state for the period 2005–16. The disease outbreaks were high in three zones namely, Central Maharashtra Plateau, Western Maharashtra Plain and Western Ghat zones districts of Maharashtra. Thus, appropriate preventive vaccinations against BQ, FMD, PPR, SF in Ahmednagar, Anthrax (SG), ET in Pune and HS in Latur districts need to be undertaken to mitigate the livestock diseases in Maharashtra 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 to identify disease free zones by doing preventive vaccinations in these zones for these diseases, which will benefit the livestock farmers, various stake holders and also to increase the economy of the country.

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