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EPIDEMIOLOGICAL INSIGHTS INTO THE ANTHRAX OUTBREAK IN MUDDABALLI VILLAGE, KARNATAKA: A CASE REPORT

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ABSTRACT
Anthrax, caused by *Bacillus anthracis*, is a persistent global threat to both public health and livestock industries. This study investigates a recent outbreak of sheep anthrax in Muddaballi Village, Karnataka, India. The demographic and ecological characteristics of this region are pivotal factors influencing disease emergence, with varying outbreak years observed among sheep farmers. Socio-economic factors and Risk Exposure and Mitigation Behavior (REMB) were found to be critical determinants of anthrax incidence, emphasizing the multifaceted nature of the disease's spread. Sheep migration and proximity to water bodies, notably the Tungabhadra reservoir, facilitated spore transfer and contributed to the outbreak in this village. The study highlights the urgency of proactive measures, including comprehensive disease surveillance, vaccine accessibility, training initiatives for local veterinarians and farmers, and the integration of AI tools for early detection and rapid response.

KEYWORDS: Anthrax outbreak, Sheep anthrax, Disease surveillance, Livestock trading, Disease prevention.

INTRODUCTION
Anthrax is an acute, infectious, non-contagious, zoonotic disease that remains a threat to public health throughout the world. The causative agent of anthrax is *Bacillus anthracis*, which is a rod-shaped, spore-forming, soil-borne bacterium that survives in the soil under suitable conditions for long periods of time. *B. anthracis* is an extracellular pathogen that replicates rapidly in the blood, conquering high density to make the host diseased. Animals come into contact with the spores by grazing grass closer to the surface when the grass is low or scarce, or by moving herds to restricted areas when water is scarce (Suresh et al., 2022). The spores are very resistant to unfavourable environmental extremes of heat, cold, desiccation, chemicals and irradiation. The incidence of anthrax varies with the type of the soil and climate. It is many times restricted to a particular area where it is endemic and such areas are known as "Anthrax belts". Cattle and sheep are very susceptible to anthrax and dogs and cats are quite resistant. There are only few reports of anthrax outbreak in domestic animals in India. Venkatesha, et al., (2006) reported 2 anthrax outbreaks in Hassan and Kolar districts of Karnataka State. The outbreak investigation team initiated an expedition to scrutinize the suspected outbreak in Muddballi Village, equipped with extensive preliminary data encompassing clinical diagnoses obtained from previously recorded cases, including reports from the Institute of Animal Health (IAH), the Veterinary Bureau (VB), and veterinary officers in the respective area.

Case presentation: Demography, Ecology and Population dynamics of muddaballi village, Koppal taluk, Koppal district
Muddabalii in Karnataka, India, falls under village location code 601779 and is situated in Koppal taluk of Koppal District. It is positioned 10.2 km away from the District and Sub district headquarters at Koppal. The total geographical area of village is 1048.88 hectares with coordinate's 5°12'33.4"N Latitude 75°56'12.3"E Longitude (Fig 1.0) Muddaballi has a total population of 2,450 peoples, out of which male population is 1,223 while female population is 1,227. Literacy rate of Muddaballi village is 64.90% out of which 74.65% males and 55.18% females are literate. In the village of Muddaballi, the livestock population comprises 756 cows, 82 buffaloes, 1129 sheep, and 312 goats, totalling 2279 animals (Table 2).

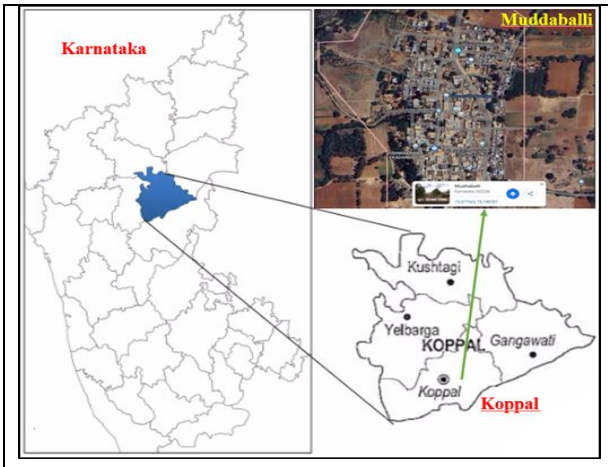

Table 1: Demography of Muddaballi Village, Koppal.	
Area	1048.88 ha
Latitude	5°12'33.4"N
Longitude	75°56'12.3"E
Altitude	526 mt
Population	2,450
Literacy rate	64.90%

Table 2: Livestock Populationn.			
Cow	Buffalo	Sheep	Goat
756	82	1129	312
Total=2279			

Fig. 1: Google map of muddaballi village, Koppal.

The ecology of Muddaballi village of Koppal district is characterized by its semi-arid climate, diverse vegetation, wildlife adapted to dry conditions, agricultural practices and the influence of human activities. The Tungabhadra reservoir, situated at Munirabad and bordering Muddaballi village, serves as a primary water resource for nearby villages and also tube wells are major source of water needs for both agriculture and livestock. The region experiences an average annual temperature of 27.0°C, receives around 587 mm of rainfall annually over 30-40 days, maintains an average annual wind speed of 5.18 meters per second, and sustains an average annual pressure ranging between 1008-1010 millibars (Table 3).

The soil type prevalent in the area is primarily composed of Red Loamy soils, which are known for their fertility and suitability for agriculture. Agriculture in this region relies on both rainfed and irrigated methods, with tube wells being a common irrigation source. Major crops cultivated in this region include maize, sugarcane, sorghum, pigeon pea, black gram, green gram, cowpea, and groundnut, reflecting a diverse agricultural landscape that caters to various food and economic needs.

Table 3: Ecological, Soil Type and Cropping pattern of muddaballi village.

1.Ave. annual Temperature	27.0 °C
2.Ave. annual Rainfall	587 mm
3.Ave. annual Rainfall days	30-40 days
4.Ave. annual wind speed	5.18mt/sec
5.Ave. annual pressure	1008-1010 mb
6. Soil type	Red Loamy soils
8. Major crops	Maize, sugarcane, sorghum, pigeon pea, black gram, green gram, cowpea,

Analyzing Patterns, Risk Factors and Community responses to sheep anthrax in muddaballi village

In a survey conducted in Muddaballi village, sheep anthrax cases were recorded among various farmers (Table 4 & Fig. 2). The analysis of anthrax incidence among sheep farmers revealed varying outbreak years. In 2023, anthrax outbreaks were noted, with several farmers reporting infected or deceased sheep. The total number of infected sheep in this year was 147 out of 600. In 2018, outbreaks occurred, affecting 22 out of 250 sheep. Further, in 2015-2016, anthrax was reported among farmers, with a total of 250 infected out of 1,230 sheep. The questionnaire responses showed that most farmers strongly agreed on the influence of socio-economic factors in anthrax incidence (Likert Scale: 5). Additionally, farmers generally acknowledged the significance of Risk Exposure and Mitigation Behavior (REMB) in anthrax prevention (Likert Scale: 4-5). However, there was variability in responses regarding the relevance of migration patterns (Likert Scale: 1-5).

Sl No.	Farmers Name	Total No of Sheep's	Infected/ Death	Year in which anthrax occurred/ not occurred	Questionnaire # (Likert Scale: 5 = strongly agree, 4= agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree)							
					Socio-economic		REMB		Migration		Preparedness	
					I	II	I	II	I	II	I	II
1.	MH	200	4	2016	5	5	5	5	5	5	5	5
2.	BP	100	20		1	5	5	4	5	4	5	5

3.	MP	150	25	2018-2021	5	4	5	4	5	5	5	5
4.	RP				5	4	5	5	5	4	5	5
5.	GH	80	8	2023	5	5	5	5	5	5	5	5
6.	BP		4	2023	2	4	5	5	5	4	5	5
7.	KH	100	10	2023	2	5	5	5	5	4	5	5

Questionnaire [#]
Socio-economical: I. Do you think you're hesitant to dispose anthrax affected carcass in a way that goes against your religious teachings? **II.** Do you think you avoid social gatherings and public spaces due to fears related to the anthrax outbreak?
Risk Exposure and Mitigation behaviour (REMB): **I.** Do you think anthrax spores can survive in the soil for extended periods, posing a risk to grazing livestock? **II.** Do you think inadequate disease surveillance measures have hindered early detection of anthrax outbreaks?
Migration: I. Do you think unregulated movement of people and livestock can contribute to the spread of anthrax to unaffected areas? **II.**: Do you think shifting of animals or change of grazing area from infected to uninfected area is effective in avoiding occurrence of anthrax?
Preparedness: I. Do you think collecting and analysing data helps identify patterns and trends in anthrax cases? **II.** Do you think prior anthrax outbreak information is important for preparedness?

DISCUSSION

Anthrax, a persistent problem in several regions, poses a public health risk due to livestock infections. Field diagnosis relies on clinical signs, such as sudden death with unclotted blood oozing from natural orifices. Mongoh et al. (2005) identified key clinical indicators as abrupt fatalities and hemorrhaging in affected animals. Anthrax outbreaks typically result from spore ingestion in soil, often linked to prior occurrences and carcass disposal. The current outbreak revealed two infection categories: per-acute, with sudden fatalities and no clinical signs, and acute, with observable symptoms and recoverable cases. Water bodies and sheep migration to the Tungabhadra reservoir contributed to spore transfer, facilitating the outbreak in this village. In Hyatti Mundaragi Village, livestock farming and trade are integral to the local economy, but pose disease transmission risks at local markets. Insufficient veterinary oversight and traditional practices exacerbate these risks. Combating disease spread through animal marketing necessitates education, quarantine measures, and collaboration with authorities to safeguard animal and human health.

CONCLUSION

The case report of the sheep anthrax outbreak in Hyatti Mundaragi Village, Koppal, Karnataka, highlights the complex interplay of factors contributing to the disease's emergence. The demographic and ecological characteristics of the region, coupled with traditional livestock trading practices, pose significant challenges in disease prevention and control. To mitigate future outbreaks, it is imperative for the government to take proactive measures. This includes allocating resources for comprehensive disease surveillance, ensuring a consistent supply of anthrax vaccines, conducting regular training sessions for local veterinarians and farmers, and establishing robust early detection and rapid response mechanisms using Artificial intelligence (AI). Engaging with the community, dispelling myths, and fostering trust is crucial, as is collaborating with international organizations to strengthen disease management efforts. Addressing these aspects holistically is essential for safeguarding the health and livelihoods of both the community and their livestock in Hyatti Mundaragi Village and similar regions.

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Authors contribution

The study on the anthrax epidemic in Muddaballi Village, Karnataka, was a collaborative effort led by Suresh K P, who served as the corresponding author and played a pivotal role in designing and executing the research. Sagar N, Jayashree A, Naveesh Y B, and Sushma R contributed significantly to data collection and analysis, particularly in gathering vital demographic and ecological information about the village. They also assisted in the analysis of collected data while providing support in manuscript editing. Suresh K P and Ramesh

Doddamani brought an international perspective, lending expertise in analyzing ecological factors and their influence on the anthrax outbreak. Hemadri D, Ramesh Doddamani and S S Patil, experts in veterinary epidemiology contributed to identifying the anthrax-prone area in Koppal and provided brief information regarding the preparation of the questionnaire, in addition to editing the manuscript.

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