Evaluating environmental and remote sensing factors in theileriosis risk prediction for bovine in Kerala, India: navigating post-flood climate dynamics

Kuralayanapalya Puttahonnappa Suresh, Siju Susan Jacob*, Pinaki Prasad Sengupta, Tarushree Bari, Dikshitha Jagadish, Paramanandham Krishnamoorthy and Sharanagouda Shiddanagouda Patil

ICAR-National Institute of Veterinary Epidemiology and Disease Informatics, Yelahanka, Bengaluru 560 064, India

Theileriosis, a parasitic disease, caused by *Theileria* spp. and transmitted through ticks, poses a significant threat to livestock, leading to elevated morbidity and mortality rates. This study investigated the incidence trend of theileriosis in Kerala, India, over three years (2019–21). Notably, the research unveiled a substantial upsurge in bovine theileriosis cases within Kerala during this period, partly attributed to the state's severe flooding and landslides in 2018, triggered by incessant monsoon rains. The present study envisaged pinpointing the risk factors underlying the prevalence of theileriosis in Kerala. Employing linear discriminant analysis, key environmental and remote sensing variables influencing the disease's incidence were identified. Subsequently, these risk factors underwent climate disease modelling, leading to the creation of risk maps. To predict areas sensitive to theileriosis outbreaks in Kerala, two regression models and nine machine learning models were employed. The gradient boost and random forest models demonstrated the most accurate fit among these. The study also estimated the basic reproduction number (R_0), which ranged from 0.89 to 1.8. This value indicates a high potential for *Theileria* spp. transmission within the study area. Consequently, the research outcomes offer valuable insights into pinpointing high risk theileriosis locations in livestock in Kerala.

Keywords: Disease prediction, Kerala, livestock, machine learning, outbreak, theileriosis.

T. lestoquardi is accountable for malignant ovine theileriosis, whereas *T. taurotragi* and *T. ovis* typically lead to asymptomatic infections[2]. The transmission of this disease involves ticks belonging to the genera *Hyalomma*, *Rhipicephalus*, *Haemaphysalis* and *Amblyomma*. The specific *Theileria* species responsible for infection determines the particular tick species implicated in transmission[3].

In India, the primary parasite responsible for bovine theileriosis transmitted by *Hyalomma anatolicum* is *T. annulata*[4]. However, *T. orientalis*, previously deemed harmless, emerged as a pathogen, causing fatal outbreaks transmitted by *Haemaphysalis* spp.[5,6]. In small ruminants, *T. luwenshuni*, *T. ovis* and *T. lestoquardi* have been identified in various states of India, including Kerala[7]. Theileriosis significantly impacts livestock, causing morbidity and mortality, as well as affecting meat and milk production, with estimated annual global losses[8]. The economic impact of bovine tropical theileriosis in India is estimated at approximately US$ 384.3 million (ref. 9), with another report revealing an even higher economic loss attributed to tropical theileriosis in India, reaching US$ 1295 million (Rs 8426.7 crores)[10]. Further, the economic loss due to tick and tick-borne diseases in India was recently estimated at 787.63 million USD (ref. 11). Kerala, once dominated by *T. annulata*, now faces *T. orientalis* ascension, sustained by carrier animals and unrestricted movement, posing a substantial threat to cattle populations, particularly cross-