2024-12-31

Extinction and persistence of lumpy skin disease: a deep learning framework for parameter estimation and model simulation

Renald, Edwiga

Springer Nature Link

https://link.springer.com/article/10.1007/s40808-024-02208-8

Extinction and persistence of lumpy skin disease: a deep learning framework for parameter estimation and model simulation

Edwiga Renald, Jean M Tchuenche, Joram Buza, Verdiana G Masanja

DOI: https://link.springer.com/article/10.1007/s40808-024-02208-8

Abstract

Lumpy Skin Disease (LSD) of cattle, an infectious and fatal viral ailment, poses a significant challenge to the farming sector due to its economic impact. A deterministic Susceptible-Exposed-Infectious-Recovered-Susceptible (SEIRS) model, is utilized in developing a Physics-Informed Neural Network—a deep learning framework for parameter estimation and simulation of LSD dynamics. The deep learning structure is presented alongside an illustration of its application using synthetic data on infectious cattle counts. To accommodate inherent variability in the model, the deterministic version is extended to a stochastic model by introducing environmental noise, assuming that biting rate is the primary source of randomness. Lyapunov second method is used to prove the existence of a unique global positive solution for the stochastic model under specified initial conditions. Subsequently, the stochastic model is employed to establish conditions for both extinction and persistence. Results of the stochastic model simulation indicate potential eradication of the disease when the environmental noise decreases. On the other hand the designed Physics-Informed Neural Network for LSD demonstrates high efficiency in model prediction and parameter estimation especially when few data is available. Analytical results underscore the importance of implementing strategies to reduce biting such as biological control methods as a means to mitigate the transmission of LSD.