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HYBRID AGENT-BASED SID MODELLING OF AFRICAN SWINE FEVER IN WILD BOAR POPULATIONS

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ABSTRACT

African Swine Fever (ASF) remains one of the most important infectious diseases affecting wild boar populations in Europe. Existing epidemiological models often simplify social structures and carcass-mediated transmission. To address these limitations, we developed a unique hybrid agent-based Susceptible-Infected-Dead (SID) model that integrates individual-based spatial mobility, fine-grained demography, and stochastically-driven environmental transmission pathways. Heavily informed by nearly a decade of the author's empirical field observations, this computational framework realistically reflects natural wild boar ethology, including complex demographic sounder structures (divided into family groups of sows leading young, yearlings, and solitary mature boars), intergroup spatial interactions, and a potent behavioral attraction to infected carcasses as major environmental reservoirs.

Stochastic simulations executed over a $300\,\text{km}^2$ (15×20 km) domain reveal three distinct density-dependent epidemiological regimes: stochastic fade-out in low-density cohorts ($N \leq 25$; density ≤ 0.1 ind./km^2), multi-phase outbreaks in medium-density populations ($N \approx 50$–150; density 0.13–0.50 ind./km^2), and self-sustaining epidemics in high-density environments ($N \geq 200$; density ≥ 0.61 ind./km^2). Crucially, our analysis of transmission kinetics demonstrates a non-linear escalation in the significance of carcass-mediated (indirect) transmission. In high-density populations, this environmental pathway becomes dominant, accounting for 70–75% of all transmission events and generating a catastrophic population mortality plateau of 90–96%. This underscores that the rapid removal of viral reservoirs from the environment must be the absolute priority for effective ASF containment, whereas traditional population reduction via hunting remains secondary.

The current SID-ABM framework has proven to be an exceptionally viable baseline for structural extensions informed by recent literature. Consequently, initial simulation prototypes of an extended SEIRD (Susceptible-Exposed-Infectious-Recovered-Dead) modelincorporating an explicit latent phase and stochastically-derived sickness behaviorare currently under development. These upcoming models will undergo collaborative calibration and empirical validation with specialized scientific units focusing on viral virology, GPS telemetric tracking, wild boar ethology, and hunting management. Ultimately, integrating this hybrid framework with GIS databases will enable real-time spatial predictions of carcass deposition and reinforce transboundary bio-border engineering within the EU regulatory framework.