Factors of endemicity in modeling the persistence of CBPP in a metapopulation of African sedentary cattle herds

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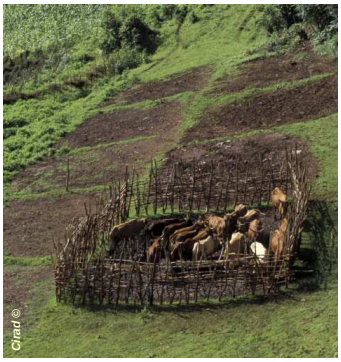
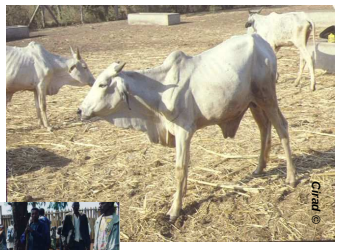
INTRODUCTION

Contagious bovine pleuropneumonia (CBPP) is a major concern in developing countries, causing livestock mortality, production losses and control costs. Modeling is necessary for better understanding regional CBPP spread and persistence, in which involvement of chronic carriers is still debated.

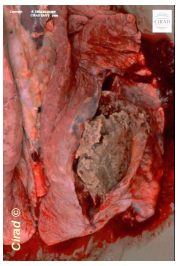
***OBJECTIVE*: to identify the most potential influential parameters on herd epidemic size and the probability of CBPP endemicity (disease persistence over more than 5 years) in a metapopulation of African sedentary cattle herds.**



An Ethiopian sedentary cattle herd



Sick animals



Sequestra in the lung

MODELING APPROACH

We have developed a stochastic metapopulation model of CBPP spread among a large number of small sedentary cattle herds of heterogeneous sizes.

The within-herd infection dynamics is modeled (Fig. 1), considering susceptible (S), latently infected (E; of duration d_E), infectious (I; of duration d_I), chronic carrier (Q; of duration d_Q), and resistant (R) animals. Chronic carriers are assumed not to be infectious, or to shed the pathogen in much a lower amount than infectious animals ($\beta_Q << \beta_I$). Herds are open with birth, death, purchase, and selling processes.

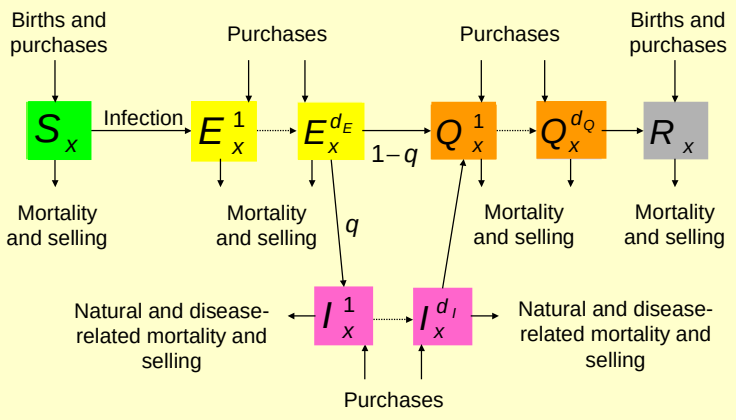


Fig. 1: Diagram of the within-herd model of CBPP spread *(from Ezanno and Lesnoff, 2008)*

The between-herd contact structure is mechanistically modeled based on animal movements in all health states.

Each herd sends animals to n other herds (network degree), representing animals loans or commercial movements.

RESULTS

Migration rate and network degree do not influence outputs. All other parameters contribute to variations in herd epidemic size and in the probability of CBPP endemicity (Fig. 2).

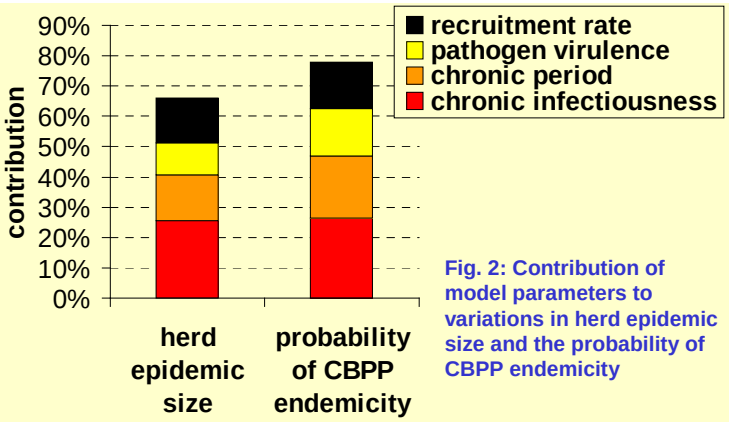


Fig. 2: Contribution of model parameters to variations in herd epidemic size and the probability of CBPP endemicity

Endemicity is most probable in the high virulence scenario, but only when chronic carriers are assumed to be infectious for at least a year, and for a medium to high level of calves recruitment (Fig. 3).

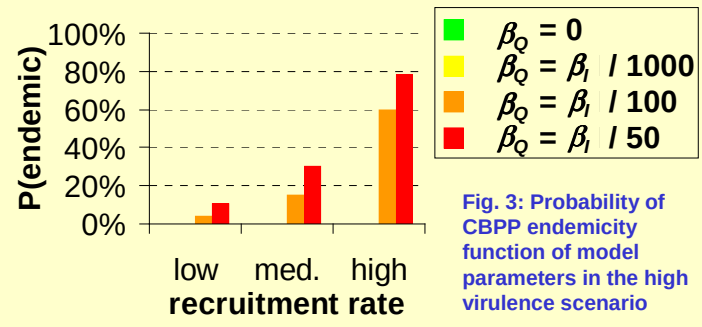


Fig. 3: Probability of CBPP endemicity function of model parameters in the high virulence scenario

CONCLUSION

CBPP endemicity as defined here and assuming no disease re-introduction is only probable if chronic carriers infectiousness is long-lasting and not too low. It becomes highly probable when assuming high pathogen virulence and level of recruitment. As a result, chronic carriers - if infectious - are a possible determinant of CBPP persistence in African sedentary farming systems. However, their ability to transmit the disease has still never been proved. CBPP persistence can also be driven by the regular re-introductions of seek animals from other endemic regions, reproducing a source-sink process. More biological research is needed on the evaluation of chronic carriers infectiousness for prioritizing these hypotheses.

REFERENCE

Ezanno P., Lesnoff M., 2008. A metapopulation model for the spread and persistence of contagious bovine pleuropneumonia (CBPP) in African sedentary mixed crop-livestock systems. *J. Theor. Biol.*, doi:10.1016/j.jtbi.2008.10.001.