Available online at www.sciencedirect.com
SCIENCE DIRECT®
Preventive Veterinary Medicine 73 (2006) 75–91
PREVENTIVE VETERINARY MEDICINE
www.elsevier.com/locate/prevetmed

A heterogeneous population model for contagious bovine pleuropneumonia transmission and control in pastoral communities of East Africa

J.C. Mariner [a,*], J. McDermott [b], J.A.P. Heesterbeek [c], G. Thomson [d], P.L. Roeder [e], S.W. Martin [f]

[a] *RDP Livestock Services, PO Box 523, 3700 AM Zeist, The Netherlands*
[b] *ILRI, PO Box 30709, Nairobi, Kenya*
[c] *Faculty of Veterinary Medicine, Department of Farm Animal Health, University of Utrecht, Yalelaan 7, 3584 CL Utrecht, The Netherlands*
[d] *Epidemiology Unit, Pan African Programme for the Control of Epizootics, African Union/Interafrican Bureau for Animal Resources, PO Box 30786, Nairobi, Kenya*
[e] *Animal Health Service, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00100 Rome*
[f] *Department of Population Medicine, University of Guelph, Guelph, Ont., Canada*

Received 27 January 2005; received in revised form 21 August 2005; accepted 1 September 2005

Abstract

Pastoral cattle live in highly structured communities characterized by complex contact patterns. The present paper describes a spatially heterogeneous model for the transmission of contagious bovine pleuropneumonia (CBPP) developed specifically for pastoral communities of East Africa. The model is validated against serological data on the prevalence of CBPP infection in several communities of southern Sudan and against livestock owner information on community structure, livestock contact and cattle exchange. The model is used to assess the impact of alternative control strategies including mass and elective vaccination programmes, potential treatment regimes and the

* Corresponding author. Present address: Department of Environmental and Population Health, Tufts Cummings School of Veterinary Medicine, 200 Westboro Road, North Grafton, MA 01536, USA.
Tel.: +1 508 839 5302/887 6762; fax: +1 508 839 7948.
E-mail address: jeffreymariner@yahoo.com (J.C. Mariner).

0167-5877/$ – see front matter
doi:10.1016/j.prevetmed.2005.09.002

combination of vaccination and treatment in a single unified strategy. The results indicate that the eradication of CBPP using mass vaccination with currently available vaccines is unlikely to succeed. On the other hand, elective control programmes based on herd level vaccination, treatment of clinical cases or a combination of both vaccination and treatment enabled individual livestock owners to capture a large benefit in terms of reduced animal-level prevalence and mortality experience. The most promising intervention scenario was a programme which combined the vaccination of healthy animals with treatment of clinical cases.

Keywords: Contagious bovine pleuropneumonia; Modelling; Basic reproduction number; Participatory; Epidemiology; Policy-making

1. Introduction

Contagious bovine pleuropneumonia (CBPP) is a major constraint to cattle production in the key pastoral regions of East Africa. Many communities rank CBPP as 1 of their top 3 animal health concerns and are highly motivated to take action to reduce losses. The disease is transmitted by direct contact and only cattle and water buffaloes are known to be affected. The usual source of infection is actively infected cases and spread occurs through their movement. Although both asymptomatic sub-acute and chronic cases are common, their role in the spread of disease has not been objectively demonstrated (Masiga et al., 1996; Windsor and Masiga, 1977). The mobility, high inter-group contact rates and importance of livestock exchange in pastoral systems create special challenges for CBPP control programs. New paradigms for CBPP control that reflect the importance and reality of pastoral livelihoods are needed.

We have previously reported on a stochastic compartmental model for CBPP transmission in pastoral herds based upon a single homogeneous population (Mariner et al., 2006). The homogeneous model integrated epidemiological data on the transmission of CBPP from diverse sources for the study of CBPP dynamics and evaluation of control options. Local livestock owner knowledge on the patterns of CBPP in traditional communities was an important component of the analysis. Experimentation with the homogeneous model found the current mass vaccination approach to CBPP eradication was unlikely to be successful with available vaccines. On the other hand, the model indicated that elective vaccination or an effective treatment regime could reduce CBPP mortality leading to important private (herd-level) benefits.

Pastoral community structure is complex in social, spatial and temporal terms. The prevalence and impact of CBPP is known to vary widely between community groups within related areas and across ecological zones. This paper describes a spatially heterogeneous population model that was developed to take our initial model 1 step further and investigate the impact of pastoral community structure and contact patterns on the dynamics of CBPP transmission and control.

The spatially heterogeneous model was used to explore control options at the individual herd level taking into account contact with the surrounding pastoral community. There are