A mathematical model for Rift Valley fever transmission dynamics

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Introduction

• Rift Valley fever:
  o Caused by arthropod-borne zoonotic RNA virus
  o Primarily affects livestock with spill-overs to people
  o Associated with substantial impacts on livestock production and trade

• We used a mathematical to:
  o Investigate RVFV transmission dynamics
  o Analyse competing prevention and control strategies
RVFV transmission cycle

Endemic Cycle

Climatic factors (heavy rainfall associated with ENSO)

Human irrigation practices

Amplification

Dry Season

Temporary ponds

Floodwater Aedes
Neomelaniconion
Aedimorphus

Floodwater Aedes + others ie Culex spp.
+ direct transmission (aerosol, contact)

Rainy Season

The virus persists during dry seasons and inter-epizootic periods through vertical transmission, inside drought resistant floodwater Aedes eggs.

Flooding results in a mass-hatching of Aedes eggs, some of which are infected, leading to a new RVF outbreak.

EFSA, 2005
Model structure

Aedes mosquitoes

Eggs\textsubscript{A} → Larvae\textsubscript{A} → Pupae\textsubscript{A} → Infected via bloodmeal → Infected transovarially

Uninfected

Eggs\textsubscript{A} → Larvae\textsubscript{A} → Pupae\textsubscript{A} → Susceptible\textsubscript{A}

Culex mosquitoes

Eggs\textsubscript{C} → Larvae\textsubscript{C} → Pupae\textsubscript{C} → Susceptible\textsubscript{C} → Infectious\textsubscript{C}

Livestock

Susceptible → Exposed → Infectious → Recovered

People

Susceptible → Exposed → Infectious → Recovered
Emergence/survival of immature mosquitoes

Endemic cycle

10 – 15 days

Epidemic cycle

4 – 6 weeks

Duration of flooding

Fuzzy function

Logit model fitted to data – 2006/2007 RVF outbreak
Model components

Rainfall – satellite data and statistical modelling
One-Health interventions: reactive vaccination 2 months before an outbreak

- Vaccinating animals – beneficial effects in humans
- Efficacy of the vaccine
Reactive and prophylactic vaccination

What vaccination levels are required to stop an outbreak (reduce incidence <10%)
Vector control

• Analysed but found not to be feasible
  – Need to sustain high vector mortality levels for prolonged time to achieve impact

Summary

• Models can provide informative insights e.g. levels of effort required to control a disease
• Discussions with policy makers on control options
• RVF – scanty data as the disease occurs infrequently
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