Participatory Epidemiology and the Use of Models to Design Control Strategies
Participatory Epidemiology

The use of participatory rural appraisal techniques to collect epidemiological knowledge and intelligence
Participatory Rural Appraisal (PRA)

• Qualitative intelligence gathering process
• Key informants
• Problem solving
  – Multiple methods
  – Multiple perspectives
  – Triangulation
• Best-bet scenarios
Existing Veterinary Knowledge

- Traditional terms and case definitions
- Clinical presentation
- Pathology
- Vectors
- Reservoirs
- Epidemiologic features

Photo: T. Leyland
Applications

- Basic Research
- Active Surveillance
  - Participatory Disease Surveillance (PDS)
- Holistic Needs Assessment
  - Stakeholders, livelihoods and risk
- Impact Assessment
  - Participatory Impact Assessment (PIA)
  - Qualitative and Quantitative
- Institutional change
Participatory Disease Surveillance

PDS

- Active surveillance done by professionals
- Risk-targeted
- High detection rate
  - Information networks
  - Extended time frame
- Sensitive and Specific
  - Validation processes
  - Laboratory support
- Timely
Diagram:

- Kantor Pucuk
- Lapangan
- Rumah
- Area Taman
- Area Pemancingan
- Area Permainan

Legend:

- '\text{Rt 1 Rt 2}': Route
- '\text{AI 16 Aug 06}': Event
- '\text{Kematian spalang ke kampung}': Event
- '\text{Kematian Membantu}': Event

Location:

- \text{Brasier Farm}
- \text{Brasier Farm}

Reported by Wihin
PDS ? \\

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Attributes of PE/PDS Programs

- Flexible approach that allows for discovery
- Practitioners are problem-solvers and not enumerators
- Strength of the approach lies in its flexible and qualitative nature
- Orients and complements, but does not replace structured and quantitative methods
- Information from diverse sources and methods
- Analyzed in an iterative process referred to as triangulation
- Integrates biological testing and quantitative methods when appropriate to objectives
PENAPH
Participatory Epidemiology Network for Animal and Public Health

• Nine core partners

• Building Surveillance Capacity

• Good Practice Guidelines

• Certification of Training

• Research, Policy and Advocacy

• Pro-Poor and One Health Focus

• Knowledge Exchange
Appropriate Combinations of Complimentary Techniques

- Participatory methods
- Biological testing
- Analytical methods
Participatory Approaches to the Mathematical Modelling of Rinderpest and CBPP

PARC, PACE and CAPE
Modelling Objective

- Model agents and lineages as they occurred in pastoral areas of East Africa
- Involve stakeholders at all levels in design and address principal questions of pastoralists and policy-makers
  - More useful and creates a sense of ownership
- Inform policy dialogue leading to more effective strategies
  - Targeting interventions and surveillance
Data Collection

- Evidence-based literature review
- Participatory epidemiology – expert opinion
  - Mortality, prevalence, clinical course, spatial and temporal patterns and contact structure, estimation of $R_0$
  - SSI, proportional piling, matrix scoring, relative prevalence scoring, mapping and event trees
- Serology - Estimation of $R_0$
“Some of us believe we have rinderpest, but we are not really sure. The disease looks like rinderpest, but it doesn’t kill the animals. It is rinderpest-like or mild rinderpest.”

Somali elder on lineage 2 rinderpest

*El Wak, Somalia 1996*
Modelling Approach

• State-Transition
• Stochastic
  – Critical Community Size
  – Fade - Out
• Open Population
• @ Risk Software
• Input Parameters – Beta Pert Distributions
• Single population and multipopulation
• Outputs – Probability Distributions
RP Model Structure

\[ S \quad E \quad I \quad R \]

- \( b \): birth rate
- \( \beta \): effective contact rate
- \( \gamma \): latency to infectious rate
- \( \mu \): non-specific mortality rate
- \( \sigma \): RP mortality rate
- \( \alpha \): recovery rate

\( S = \) Susceptible, \( E = \) Exposed, \( I = \) Infectious, \( R = \) Resistant
CBPP Model

\[ V \]  
\[ S \]  
\[ E \]  
\[ I \]  
\[ R \]  
\[ Q \]  

\[ \mu \]  
\[ \beta \]  
\[ \gamma \]  
\[ \alpha_r \]  
\[ \kappa \]  
\[ \psi \]  
\[ \mu \]  

\[ \rho \]  
\[ \omega_v \]  
\[ \omega_r \]  
\[ \mu \]  
\[ \sigma \]  
\[ \alpha_d \]  
\[ \mu \]  

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\[ \mu \]
The Basic Reproductive Number $R_0$

- Number of secondary cases resulting from one infected animal in susceptible population
- $R_0$ is a feature of both the strain of infectious agent and the host population
The Importance of $R_0$

• A measure of the transmission rate
• Can be easily estimated from field data
  – RP - Herd immunity threshold ($1 - 1/R_0$)
  – CBPP - Average of first infection
  – HPAI – Final fraction size
• Effective contact rate, $\beta$, can be calculated from $R$ nought.
• Herd immunity targets
Inter-Epidemic Period
Rinderpest in Sudan and Somalia
Temporal distribution of reports on rinderpest compatible events by year and interview area
So What?

- **Prevalence of Infection**
  - 0.1 – 0.2 %
  - Random clinical surveillance to OIE standards (1%) not useful
  - Participatory disease surveillance

- **Critical Community Size**
  - ~200,000 head
  - Target vaccination to high risk populations
  - Large, remote pastoral communities

- **Lineage 2 in Somalia**
  - Modest herd immunity levels could eradicate
Disease Persistence as a Function of the Initial Prevalence of Immunity
Traditional Livestock Exchange
Heterogeneous RP Model for lineage 2 in the Somali Ecosystem

- Four populations
- Multiple species
  - Parameter values can set independently
- Eight year duration
- Cattle and buffaloes
- Buffalo $R_0 \sim 8$
Four Sub-Population Epidemic Curves from a Heterogeneous Population Model for Rinderpest in Cattle Where the Between Population Contact Rate is 1% of the Within Population Contact Rate
Results Over 2 Years

- Mean mortality 0.85% per year
- 34% of iterations ended with a prevalence of infection of 0.1 to 1%
- Maximum prevalence 2%
- Final average immunity 26%
Eight Year Model
\( \eta = 0.005 \) and \( R = 35\% \)

<table>
<thead>
<tr>
<th>Duration</th>
<th>Mean</th>
<th>95(^{th}) %</th>
<th>Max</th>
<th>Persistence (%)</th>
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<td>10,000</td>
<td>137</td>
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The Role of Buffaloes

<table>
<thead>
<tr>
<th>Buffaloes % Immune</th>
<th>Cattle - Day of Last Case</th>
<th>Overall – Day of Last Case</th>
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<tbody>
<tr>
<td>5-15</td>
<td>245</td>
<td>247</td>
</tr>
<tr>
<td>15-25</td>
<td>264</td>
<td>269</td>
</tr>
<tr>
<td>25-35</td>
<td>261</td>
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<td>45-55</td>
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<td>265</td>
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<tr>
<td>55-65</td>
<td>253</td>
<td>260</td>
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</table>
Somali Ecosystem

- Buffalo act as an indicator host and do not contribute to persistence in cattle
  - Explosive outbreaks of short duration
- Small isolated communities can maintain Lineage 2 for prolonged periods
- Intensive surveillance and time
### Potential of a Combined Vaccination and Treatment Strategy for CBPP

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Baseline 1/α</th>
<th>75% 1/α</th>
<th>50% 1/α</th>
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<tr>
<td>None</td>
<td>75.4</td>
<td>59.6</td>
<td>33.2</td>
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<tr>
<td>Annual – 5 yr</td>
<td>67.8</td>
<td>43.0</td>
<td>7.6</td>
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<tr>
<td>Biannual – 2 yr</td>
<td>57.2</td>
<td>-</td>
<td>4.4</td>
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<tr>
<td>Biannual – 5 yr</td>
<td>35.2</td>
<td>8.0</td>
<td>0.4</td>
</tr>
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Indications from the CBPP Modelling

• Eradication not possible with existing vaccine without severe movement control

• The potential impact of treatment is at least great as available vaccines
  – Private sector and consumer driven application

• Research on treatment regimes merits the same level of attention and investment as vaccine development.
Conclusion

• Simple, intuitive models serve as good communications tools for underlying concepts
• Bring diverse information together to be tested as for biological coherence
• Choose between strategy options or identify new options
• Involve beneficiaries and decision-makers from the outset.