Rift Valley Fever - Vector Reservoirs, Inter-epidemic maintenances of the virus

RVF Workshop - An integrated Approach to Controlling Rift Valley Fever (RVF) in Africa and the Middle East. Jan 27th - 29th Cairo, Egypt.

DR. ROSEMARY SANG
(KEMRI & USAMRU- Kenya)
RVF, Introduction

- Mosquito-borne disease caused by a Phelebovirus, Bunyaviridae family
- Affects wide range of mammals - man and domestic livestock
- Epidemics prone disease, impacting human/animal health
- Devastating economic and social consequences.
Epidemic Transmission Cycle

1. Abnormal sustained flooding

2. Large mosquito populations

**OTHER ROUTES:** Contact with infected animal blood, tissue & milk
RVF – vector species diversity

Genera:
- Aedes
- Culex,
- mansonia
- Amblyomma variegatum
- Culicoides.

- RVFV isolated from wide range of vector species
- Experimentally, a wide variety of species can transmit RVF
- There is world wide distribution of potential vector of RVFV
- e.g. Recent studies in France and Tunisia (2008) found competent vectors

!! Hence likely spread of the virus.
VECTORS IN MAJOR OUTBREAKS

- Kenya 1950/1951 - Over 100,000 livestock dead
  - Vectors not documented

- Egypt - 1977 - First Major human involvement
  - Vectors \textit{Culex pipiens}.

- West Africa 1987 - Senegal & Mauritania
  - Irrigation project + heavy rains
  - Vectors \textit{Ae. vexans, Ae. Ochraceous, Culex poicilipes}

- East Africa/Kenya 1997/98 - Kenya, Tanzania, Somalia
  - Human and animal catastrophe
  - Entomologic investigations NOT documented

- Saudi/Yemen - 2000/2001
  - Vectors \textit{Ae. Vexans arabiensis, Cu. tritaeniorhynchus}

- East Africa/Kenya 2006/07 - Kenya, Tanzania, Somalia
  - Due to earlier detection (than 97/98)
  - Peak timing of extensive entomologic surveillance
Previous inter-epidemic surveys Implicated many species as RVF vectors in Kenya

<table>
<thead>
<tr>
<th>Aedes</th>
<th>Culex</th>
<th>Mansonia</th>
<th>Anopheles</th>
</tr>
</thead>
<tbody>
<tr>
<td>mcintoshi</td>
<td>zombaensis</td>
<td>africanus</td>
<td>pharoensis</td>
</tr>
<tr>
<td></td>
<td>vansomereni</td>
<td></td>
<td></td>
</tr>
<tr>
<td>circumluteolus</td>
<td>theileri</td>
<td></td>
<td>christyi</td>
</tr>
<tr>
<td></td>
<td>antennatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dentatus</td>
<td>rubinotus</td>
<td></td>
<td>squamosus</td>
</tr>
</tbody>
</table>
In October/Nov 2006, reports of heavy persistent rains in NEP - Kenya + severe flooding

On 22nd Dec 2007, outbreak of RVF was declared by GK.

On 14th Dec GEIS/WRP & KEMRI surveillance team moved to Garissa to assess impact of flooding

Entomologic survey continued through the outbreak
Laboratory testing of entomologic collections from Garissa, Kilifi, Baringo and Kirinyaga was done:

- To determine and document vector species involved in RVF outbreaks in the diverse ecologies.

Later

- To determine the competence of implicated vectors.

- Determine their host preference.
THE SAMPLES CAME FROM DIVERSE ECOLOGIES IN KENYA

- Baringo (19) (Lake side Swampland)
- Garissa (51) (Arid scrub land)
- Kirinyaga (0) (Montane forests)
- Kilifi (7) (Mangrove, coastal forest)

RVF Entomological Investigations (14 Dec - 14 Mar)
MOSQUITO COLLECTION

- Mosquitoes sampled using standard CO\textsuperscript{2} baited light traps
- Set overnight around affected homes, villages, animal pens
- Trapped mosquitoes taken in the morning
MOSQUITO IDENTIFICATION

A team effort
Each species was grouped in pools (up to 25/pool). Those with blood in gut were set aside for subsequent host ID.

Pools homogenised in medium with serum and antibiotic supplements

RVFV RNA extracted from homogenates

Amplified RVF confirmed by sequencing PCR product

RNA amplified by RT-PCR (using RVF Specific primers)
TESTING - CAPACITY BUILDING

USAMRIID
PROCEDURES WITH LAB SAFETY

BSL-3

Homogenisation of mosquito pools and virus RNA extraction
PCR LABORATORY

Virus RNA amplification and detection
**Virus Detection in Mosquito Species in Garissa**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SITES</th>
<th>TESTED POOLS</th>
<th>% PROPORTION OF COLLECTION</th>
<th>RVF +VE POOLS</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ae. mcintoshi</em></td>
<td>Garissa</td>
<td>500</td>
<td>42.3</td>
<td>26</td>
</tr>
<tr>
<td><em>Ae. ochraceous</em></td>
<td>Garissa</td>
<td>450</td>
<td>30.0</td>
<td>23</td>
</tr>
<tr>
<td><em>An. squamosus</em></td>
<td>Garissa</td>
<td>88</td>
<td>5.9</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>1038</strong></td>
<td><strong>78.2%</strong></td>
<td><strong>51</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Ae. pembaensis</strong></td>
<td>Kilifi</td>
<td>65</td>
<td>23.2</td>
<td>1*</td>
</tr>
<tr>
<td><strong>Cx. poicilipes</strong></td>
<td>Kilifi</td>
<td>100</td>
<td>38.6</td>
<td>3</td>
</tr>
<tr>
<td><strong>Cx. bitaeniorhynchus</strong></td>
<td>Kilifi</td>
<td>22</td>
<td>8.0</td>
<td>3*</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>187</td>
<td>69.8</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

*First time detection of RVFV in species
# Virus Detection in Mosquito Species from Baringo

<table>
<thead>
<tr>
<th>Species</th>
<th>Location</th>
<th>Count</th>
<th>Percentage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cx. quinquefasciatus</em></td>
<td>Baringo</td>
<td>75</td>
<td>4.0</td>
<td>1</td>
</tr>
<tr>
<td><em>Cx. univittatus</em></td>
<td>Baringo</td>
<td>8</td>
<td>0.3</td>
<td>1</td>
</tr>
<tr>
<td><em>Ma. uniformis</em></td>
<td>Baringo</td>
<td>804</td>
<td>66.8</td>
<td>15</td>
</tr>
<tr>
<td><em>Ma. africanus</em></td>
<td>Baringo</td>
<td>327</td>
<td>20.2</td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>1214</td>
<td><strong>91.3</strong></td>
<td>19</td>
</tr>
</tbody>
</table>
# Infection Rates Garissa

<table>
<thead>
<tr>
<th>Site</th>
<th>RVF+ Sp</th>
<th>IR*</th>
<th>Limits</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>ElHumow</td>
<td><em>Ae. ochraceous</em></td>
<td>2.54</td>
<td>1.53 – 3.98</td>
<td>6,192</td>
</tr>
<tr>
<td></td>
<td><em>Ae. mcintoshi</em></td>
<td>2.38</td>
<td>1.48 – 3.64</td>
<td>“</td>
</tr>
<tr>
<td></td>
<td><em>An squamosus</em></td>
<td>1.11</td>
<td>0.20 – 3.64</td>
<td>“</td>
</tr>
<tr>
<td>Kurabul</td>
<td><em>Ae. mcintoshi</em></td>
<td>2.0</td>
<td>0.53 – 5.41</td>
<td>178</td>
</tr>
<tr>
<td></td>
<td><em>Ae. ochraceous</em></td>
<td>1.97</td>
<td>0.52 – 5.33</td>
<td>“</td>
</tr>
<tr>
<td>Dertu/Shan</td>
<td><em>Ae. ochraceous</em></td>
<td>10.65</td>
<td>1.97 – 36.11</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td><em>Ae. mcintoshi</em></td>
<td>1.25</td>
<td>0.07 – 6.08</td>
<td>“</td>
</tr>
<tr>
<td>Desai</td>
<td><em>Ae. ochraceous</em></td>
<td>1.11</td>
<td>0.20 – 3.63</td>
<td>516</td>
</tr>
<tr>
<td></td>
<td><em>Ae. mcintoshi</em></td>
<td>0.83</td>
<td>0.15 – 2.71</td>
<td>“</td>
</tr>
</tbody>
</table>

Pooled infection rates – Bias corrected maximum likelihood infection rate/1000
<table>
<thead>
<tr>
<th>SITES</th>
<th>RVF + Sp</th>
<th>IR</th>
<th>LIMITS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Logumgum (Baringo)</td>
<td><em>Cx. Univittatus</em></td>
<td>18.01</td>
<td>1.32 – 118.01</td>
<td>5,269</td>
</tr>
<tr>
<td>&quot;</td>
<td>Ma. uniformis</td>
<td>0.89</td>
<td>0.52 – 1.44</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot;</td>
<td><em>Cx. quinquefaciatus</em></td>
<td>0.71</td>
<td>0.04 – 3.42</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot;</td>
<td>Ma. africana</td>
<td>0.33</td>
<td>0.06 – 1.08</td>
<td>&quot;</td>
</tr>
<tr>
<td>Gongoni (Kilifi)</td>
<td><em>Cx. bitaeniorhyn</em></td>
<td>6.92</td>
<td>1.84 – 18.94</td>
<td>63</td>
</tr>
<tr>
<td>Tezo</td>
<td><em>Cx. poicilipes</em></td>
<td>1.28</td>
<td>0.34 – 3.46</td>
<td>&quot;</td>
</tr>
<tr>
<td>Uyombo</td>
<td><em>Ae. pembaensis</em></td>
<td>0.65</td>
<td>0.04 – 3.17</td>
<td>&quot;</td>
</tr>
</tbody>
</table>
**IMPLICATION**

**Garissa/ Baringo**

- 77 RVFV isolates, 51 (66%) from Garissa – 19 (24.6%) from Baringo.

- Garissa and Baringo reported highest numbers of suspected human cases

- Both pastoralist zones. Livestock are kept in large herds aids virus amplification.

- Both - flood prone terrain, & high temperatures

- suited for high mosquito densities, rapid virus growth in vectors (short EIP) and hence higher transmission rates.
DISCUSSION

- This is one of the most comprehensive entomologic survey undertaken in a RVF outbreak in Kenya.

- Attributed to the pre-existing surveillance activities by GEIS & KEMRI

- Findings indicate that different mosquito species serve as epizootic and/or epidemic vectors of RVFV in different ecologic settings in Kenya

- Virus infected species included previously known and new ones

- This presents a complex epidemiologic pattern of RVFV in Kenya

- Any effort to come up with control strategies must put this into account
FIGURE 3. Number of reported Rift Valley fever cases (n = 330), by date of illness onset — Kenya November 2006–January 2007*

*As of January 25, 2007, for cases with known date of onset.
The average number of days between key events:

- Heavy Rains: 20.9 days
- Mosquito Swarms: 20 days
- First Livestock Cases: 10.9 days
- First Human Cases: 10.9 days
- First medical intervention: 7.2 days
- First Veterinary Intervention

19 Oct 30 Oct 17 Nov 30 Nov 11 Dec 14 Jan

WHO declared human index case
GEIS early warning out
EMPRES warning to gov'ts

How effective disease prevention can be achieved? - **Stop the transmission!**

1. Advanced Larviciding will:
   - avoid high vector densities
   - reduce vector infection rates
   - reduce virus transmission & amplification
   - reduce animal exposure <<< human exposure

3. Adulticides – During outbreak to reduce transmission – Too late

4. Livestock -insecticide treatment (pour on)?
   - movement of livestock from vector swarms
SUGGESTIONS

- Vector surveillance necessary in outbreak hotspots/regions during IEP:
  - to facilitate early detection/prevention
  - Identify IEP maintenance mechanism
  - Localise emergence zones (vectors/reservoirs)

- Analysis of blood in fed specimens
  - Extent virus transmission to human by mosquitoes,
  - Identification of other possible reservoirs, the range of other hosts involved.
Acknowledgements

- KEMRI
- USAMRU Kenya - GEIS
- CDC - Kenya
- CDC - Fort Collins
- NAMRU 3
- USAMRIID
- NASA, Godard Earth Science
- USAID
- Kenya’s MOPH&S and MOHS + their staff, Garissa, Kilifi, Baringo AND Kirinyaga
AND TO THE PEOPLE

THANK YOU