Pest forecasting- Japanese encephalitis, leptospirosis, aflatoxicosis

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Johanna Lindahl
This presentation

• Background to the different selected diseases
  • JE
  • Leptospirosis
  • Aflatoxins
  • Etiology and epidemiology
Japanese Encephalitis
A short history

• Japanese borders opened 1853

• Summer Encephalitis 1870
• Outbreak 1924 over 6000 cases, close to 4000 deaths
• Isolated in 1935
• Japanese B Encephalitis (Von Economo’s Encephalitis Lethargica was A)
Japanese encephalitis

A zoonotic disease
Fatal encephalitis in humans and horses - most common cause of viral encephalitis in humans
Reproductive disease in swine - well described in epidemic areas

Population density (FAO stats estimates)

- 3 billion live in endemic areas
- 60,000 human cases per year
- Case fatality 30%
The virus

- Enveloped, around 50 nm
- + ssRNA
- 5 genotypes

<table>
<thead>
<tr>
<th>C</th>
<th>prM</th>
<th>E</th>
<th>NS1</th>
<th>NS2A</th>
<th>NS2B</th>
<th>NS3</th>
<th>NS4A</th>
<th>NS4B</th>
<th>NS5</th>
</tr>
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</table>

Nucleocapsid  
Precursor for transmembrane protein  
Envelope glycoprotein  
Non structural proteins
Japanese encephalitis virus

Flaviviridae
- Pestivirus
- Hepacivirus
- Flavivirus

Flavivirus
- Dengue group
- Yellow fever group
- Mammalian Tick borne group
- Japanese Encephalitis Group

Japanese Encephalitis Group
- Japanese Encephalitis Virus
- St Louis Encephalitis Virus
- Murray Valley Encephalitis Virus
- West Nile Virus

Serological cross-reactions!
Japanese Encephalitis Virus and vectors

- A vector-borne virus - an arbovirus
- Mosquitoes, *Culex* species
  - *Culex tritaeniorhynchus*
  - *Culex pseudovishnui*
  - *Culex vishnui*
  - *Culex gelidus*
  - *Culex annulirostris*
  - *Culex quinquefasciatus*

Ss-RNA virus mutates rapidly - but not when vector-borne

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Culex vishnui subgroup
Vector capacity and competence

\[ k = \text{Probability that a vector feeding on an infected host gets infected.} \]

\[ P_f = \text{Probability that a vector survives from one meal to the next.} \]

\[ P_e = \text{Probability that a vector survives the Extrinsic incubation period, EIP} \]

\[ Q = \text{Probability that a vector feeds from the right host – blood index for the host.} \]

\[ H_{Br} = \text{Host biting rate, the number of vectors feeding from an animal per day.} \]

\[ v = \text{Probability of pathogens becoming infectious in the vector} \]

\[ C = \text{Vector capacity} \]

\[ C = H_{Br} Q v k P_e / (1 - P_f) \]
Uptake of the pathogen

- Foregut
- Midgut
- Peritrophic membrane
- Gut barrier
- Hindgut
Vertical transmission

• Due to infections of the eggs while virus circulates in haemolymph
• Showed in experiments
• Naturally infected Mansonia and Culex males found

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Pig keeping in the Mekong area

• Majority smallholders 1-2 sows
• Growing number of larger commercial farms
• Often a combination of gardening, aquaculture, livestock and rice fields
• Almost half of Vietnamese rural households have pigs
• In 2008 26.8 million pigs in Vietnam, 3.6 million in Mekong delta
• Pork is 70% of meat consumption in Vietnam, over 50% in Cambodia
The importance of pigs

- Pigs important for smallholders
- Popular in Southeast Asia
- In Vietnam common with family farms
- Increasing number of large commercial farms
- More exotic breeds and AI
FAO statistics
Number of heads in selected country 1993 - 2013

M = Million, k = Thousand
How do people keep pigs, and why is it important?
• Keep it close to home for fear of theft, or because you have to take care of it
• Keep it in the house because no other space
• Keep it scavenging because there is no feed
Genotypes distribution and spread

Only one serotype!
Disease in humans and horses

- Incubation period 6-10 days
- Fever, headache and meningitis
- Coma, death
JEV and reproduction- pigs

- SMEDI: Stillbirth, mummification, embryonal death, infertility
- Middle third of pregnancy most affected
- Immunocompetence after 65-70 days
- Boars: orchitis, aspermia
- Differential diagnoses: PRRS, AD, CSF, leptospirosis, parvo
How much impact on reproduction in an endemic area?

Sows sampled 1999

- 315 serum samples analyzed with IgG ELISA
- 60% had antibodies
- Increasing odds for seropositivity with increasing age

![Seroprevalence graph showing the percentage of sows below 1.5 years, between 1.5 and 3.5 years, and over 3.5 years with varying levels of seropositivity.

<1.5 year: 50%
1.5-3.5 years: 70%
>3.5 years: 90%

The graph indicates a clear trend with increasing seropositivity with age.}
Association with stillborn piglets

- There was no association when all sows were included
- In sows <1.5 years more stillborn piglets with increasing OD-values
Too cold for mosquitoes

Mosquitoes start breeding

Infections in animals

Infections in humans
Implications for human epidemiology

- When JEV is newly introduced- many clinical cases, of all ages
- When endemic- most adults are immune, mainly children sick
- When childhood vaccination- fewer cases, but if low infection pressures, may see cases among elderly
Urban presence of JEV?

- 43 female pigs sampled in the urban Ninh Kieu district
- 31 female pigs sampled in the rural Co Do district
- 73/74 were seropositive in an IgG ELISA
- 0/74 positive in an IgM ELISA
Collected mosquitoes

- *Culex tritaeniorhynchus* (36%)
- *Culex gelidus* (24%)
- *Culex quinquefasciatus* (15%)
Pigs and mosquitoes

Graphs showing the mosquitoes collected in households with and without pigs in Ninh Kieu district, Can Tho city, Vietnam. Collections made close to humans are shown with thin boxes and collections close to pigs are shown with thick boxes. A; total number of mosquitoes, B; *Culex tritaeniorhynchus* C; *Culex gelidus* D; *Culex quinquefasciatus*. Circles depict outliers > 1.5 x the interquartile range and stars extreme outliers > 3 x the interquartile range.
JEV-infected mosquitoes

Household with JEV-positive mosquito pool close to pigs

Household with pigs, no positive pools

Household without pigs, no positive pools

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Epidemiological implications

- Most mosquitoes at urban households are potential vectors.
- Pig keeping increases the number of vectors.
- Close to pigs—higher risks of vectors.
Should we not keep pigs?

- Food versus risks
- Badu Island: Moved Pigs 2.5 km from the urban area: reduced the JE cases, but still could detect virus in the city
- Same situation in Singapore
- Japan increased pig numbers- decreased JE incidence
Questions remaining

What is the reservoir in nature?
Which are all the possible vectors?
How are vectors affected by climate change?

Infection in other animals?

What is the risk for emergence, especially in urban areas?
Leptospirosis
Neglected zoonoses

Deaths - annual

- Leptospirosis
- TB (zoo)
- Rabies
- Cysticercosis
- Leishmaniasis
- Brucellosis
- Echinococcosis
- Toxoplasmosis
- Q fever
- Sleeping sickness
- Anthrax
**Leptospira spp**

- Spirochete - motile, aerobic, and similar to both Gram + and Gram -
- Multiple species and serovars
- Most mammals but also other animals
- Colonizes renal tubules in carriers
- Penetrates mucosal or skin abrasions
- Direct or indirect transmission
Reservoir host Serovar(s)

- Pigs *pomona, tarassovi*
- Cattle *hardjo, pomona*
- Horses *bratislava*
- Dogs *canicola*
- Sheep *hardjo*
- Racoon *grippotyphosa*
- Rats *icterohaemorrhagiae, copenhageni*
- Mice *ballum, arborea, bim*
- Marsupials *grippotyphosa*
- Bats *cynopteri, wolffi*
Clinical symptoms

- Affinity for kidney, liver, lung
- Pigs: Often subclinical in young pigs. Diarrhea, jaundice, anorexia, reproductive failure, abortions.
- Humans: Jaundice, fever, myalgia, headache, vomiting/diarrhea, liver damage
- Case fatality in dogs can be up to 20%
Risk factors

• Water contact, poor sanitation, rainfalls and floodings
• Leptospires can survive for weeks in optimal condition, warm and wet, neutral to slightly alkaline water.
• In dogs, a lag period of 3 months after rainfall
• Some studies in pigs show association with season, some not.

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Aflatoxins
Aflatoxins are a major issue

- Estimated that total mycotoxin losses in the states are 1.4 billion USD annually
- Some years farmers are forced to dispose of half their crops of corn and peanuts
- Thailand, Indonesia, Philippines total market loss: 200 million USD (and 700 million USD costs for livestock losses and health costs)
Major effects on trade

When EU harmonized the limits:

- Decrease to 4 ppb: saves 2 lives per billion
- Europe receives 57% of African and Middle eastern exports
- Estimated to decrease African exports by 64% (670 million USD)
- Peanuts one of Africa’s few export commodities (Gambia, Senegal, South Africa)
.. And that is only the monetary values

- Acute outbreaks can claim 100s of lives (Kenya outbreak 2004-2005 150 known fatal cases)
- 4.5 billion people chronically exposed (estimate by US CDC)
- Aflatoxin one of the most potent carcinogens known

- Immunosupression
- Stunting
What are aflatoxins?

- Toxin produced by *Aspergillus* spp, mainly *Aspergillus flavus* and *Aspergillus parasiticus*
- Metabolic by-product from certain strains
- *Aspergillus flavus* toxin

http://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/ucm070664.htm
<table>
<thead>
<tr>
<th>Mycotoxin</th>
<th>Main fungi</th>
<th>Impact on animal health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxins</td>
<td>Aspergillus spp</td>
<td>All livestock susceptible to different degrees. Acute toxicity, hepatotoxic and nephrotoxic. Carcinogenic and mutagenic. Growth impairment. Immunosuppression.</td>
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<tr>
<td>Ochratoxin A</td>
<td>Aspergillus spp, Penicillium spp</td>
<td>Nephrotoxic Immunosuppression Possibly carcinogenic</td>
</tr>
<tr>
<td>Fumonisins</td>
<td>Fusarium spp</td>
<td>Toxic to liver and central nervous system Possibly carcinogenic</td>
</tr>
<tr>
<td>Zearalenone</td>
<td>Fusarium spp</td>
<td>Swine highly sensitive, cattle less sensitive. Endocrine disruption. Estrogenic effects, reduced reproduction, feminisation, malformations.</td>
</tr>
<tr>
<td>Trichotecenes</td>
<td>Fusarium spp</td>
<td>Gastrointestinal disturbance. Reduced feed intake. Ill-thrift. Immunosuppression.</td>
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</tbody>
</table>
What is so tricky?

• Invisible toxin
• Odourless
• Heat-stable
Why is the toxin there?

- Fungi infect stressed crops pre-harvest, during harvest or during storage
- Especially susceptible crops: maize, groundnuts
- Optimum temperature 37°C (range 12-48)
- Mainly tropical disease

Photo by IITA. Aspergillus naturally infected groundnuts in Mozambique.
What promotes the fungal growth?

• Pre-harvest: damage by insects, draughts
  • Insects cause damage and are mechanical vectors

• Post-harvest: Poor storage conditions
The consequences of export barriers

- The best products are exported
- The bad products are left to the national markets

Photo by IITA.
Climate change
Climate change and emergence

• More irregularities in rain seasons
  • Floodings
  • Droughts
Emergence of diseases

- Population growth
- Increasing globalization
- Increased urbanization
- Climate changes
- Agricultural changes
Socio-economic drivers

• If you live on the streets:
• Can you protect yourself?
• Will you be reached by health measures?
• Will your cause of death be reported?

• Living standards decrease risks
• Proper building
• Mosquito nets
• Air condition
**Suspected challenges**

- **JEV**: High vaccination levels in Vietnam. Most infections subclinical. Vaccination only good prevention.
- **Lepto**: Underdiagnosed. Un-controlled rodent populations. What can we do with forecasting?
- **Aflatoxins**: Virtually unknown status. What can we do to mitigate?
One Health

Food safety and security

Livelihood

Zoonoses
Thank you for your attention!