Updates and further analyses for mapping the zoonotic niche of Ebola virus disease in Africa

David Pigott; pigottdm@gmail.com
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Where to improve?

- Many possible additions to be made (often limited by data)
- Two areas to focus
  - Data
  - Additional species

Picture: Freya Shearer (based upon Peterson et al. 2008)
New sources of data

• Re-assessment of data inclusion, particularly for potential reservoirs
• Sourced two references for infection in animals and one new human outbreak
EVD in DRC 2014

- July 6th until October 7th 2014
- Originated in Inkanamongo village, near Boende
- In total 66 probable/confirmed cases and 49 probable/confirmed deaths

Maganga et al. (2014)
Additional animal sources

• Morvan et al. (1999) Microbes and Infection
  o survey 242 small mammal organs collected from across Central African Republic – seven individuals found to be PCR positive for Zaire Ebolavirus
  o Three rodent species in total – Peter’s mouse (*Mus setulosus*), *Praomys* spp. and Great forest shrew (*Sylvisorex ollula*)

• Ogawa et al. (2015) Journal of Infectious Diseases
  o 748 sera collected from fruit bats (*Eidolon helvum*) and tested for filovirus specific IgG antibodies
  o 71 positive sera detected
Updated occurrence database

[Map of Africa with markers indicating updated human and animal occurrences]
Suspected life-cycle of Ebolavirus
Improving bat estimates

• Supplementation of GBIF data points using literature review
• Sourced from PubMed and Web of Science
  ○ Geopositioned following same protocols for animal Ebola case dataset
Group 1 bats

- E. franqueti
- H. monstruosus
- M. torquata
- All Tier 1 Bats

Bat occurrence records
IUCN species range

Institute for Health Metrics and Evaluation
Broadening the bats considered

• A number of African species have serological evidence of ebolavirus disease
  o Included as data points but not in the reservoir consideration
  o Used Olival and Hayman (2014) *Viruses* as basis for including ebolavirus seropositive bats
Define different bat groups

**Group 1 – RNA positive**
- Franquet's epauletted fruit bat
- Little collared fruit bat
- Hammerheaded fruit bat

**Group 2 – Seropositive**
- Angolan free-tailed bat
- Egyptian rousette
- Gambian epauletted fruit bat
- Straw-coloured fruit bat
- Peter's dwarf epauletted fruit bat
Group 2 bats

T. condylura

E. gambianus

M. pusillus

R. aegyptiacus

E. helvum

All Tier 2 Bats
Broadening the bats considered

- Using machine learning to identify other species with traits in common with filovirus positive species
- Methodology developed by Barbara Han and colleagues (publication to come in PLoS NTDs)
Trait based classification

R2D3 - A Visual Introduction to Machine Learning
http://goo.gl/MYiqRh
Group 3 bats
Revising niche estimates

• Two iterations
  (a) Model using three bat groupings as covariates
  (b) Model using all separate bats layers as covariates
Revised niche map

Using three bat groups
Difference Map

Using three bat groups

Countries with reported index cases
Countries at risk without reported index cases
Comparing model outputs

<table>
<thead>
<tr>
<th>Original eLife publication</th>
<th>Revised model (with bat groupings)</th>
<th>Revised model (with individual bat layers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EVI mean (0.65)</td>
<td>EVI mean (0.55)</td>
<td>EVI mean (0.46)</td>
</tr>
<tr>
<td>Elevation (0.12)</td>
<td>Group 1 bat (0.18)</td>
<td><em>H. monstruosus</em> (0.15)</td>
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<tr>
<td>LST mean [night] (0.08)</td>
<td>LST mean [night] (0.08)</td>
<td><em>E. franqueti</em> (0.08)</td>
</tr>
<tr>
<td>PET mean (0.06)</td>
<td>Elevation (0.06)</td>
<td><em>O. martiensseni</em> (0.06)</td>
</tr>
<tr>
<td>Bat distribution (0.04)</td>
<td>LST mean [day] (0.04)</td>
<td><em>E. labiatus</em> (0.04)</td>
</tr>
<tr>
<td>AUC – 0.85±0.04</td>
<td>AUC – 0.824±0.08</td>
<td>AUC – 0.818±0.08</td>
</tr>
</tbody>
</table>
Bat layers explaining variation
Population at risk

Countries with reported index cases
Countries at risk without reported index cases
Population at risk
Population at risk

[Bar chart showing population at risk for various countries]
Acknowledgements

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Next steps