What impact of climate change on animal health?

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UMR CIRAD-INRA “Contrôle des maladies animales exotiques et émergentes”

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Outline

1. Vectors and vector-borne infections as models of the effect of climate change on health

2. How climate change can affect animal (and human) health?
   - Direct effects
   - Indirect effects

3. How can we quantify changes?
   - Climate changes & meteorological events
   - Vector & health data

4. Requirements and perspectives for assessing impacts of climate change on health
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Why bothering?

French municipalities with at least one clinical case of bluetongue reported in 2007-2008 ($n = 10,994$) (Pioz et al., 2011)
Vectors & vector-borne infections

- **Hematophagous arthropods:** insects, ticks

  Tiger mosquito *Aedes albopictus*

  Dengue, chikungunya...
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- **Extrinsic cycle**: pathogen multiplication within the vector

*Culicoides imicola*

Bluetongue, Schmallenberg…
Vectors & vector-borne infections

- Hematophagous arthropods: insects, ticks
- Get infected through blood meal on an infected host
- Extrinsic cycle: pathogen multiplication within the vector
- Pathogen transmission during the next blood meal

Tick *Ixodes ricinus*

Lyme borreliosis, tick-borne encephalitis...
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$R_0$: basic reproduction number

- Epidemic risk: if $R_0 > 1$, epidemics may occur
- $R_0$ for malaria: *Plasmodium* parasite transmitted to humans by *Anopheles* mosquitoes

\[
\begin{align*}
  R_0 &= C \times b \times \frac{1}{r} \\
  C &= \frac{m \times a^2 \times p^n}{-\log(p)}
\end{align*}
\]

where

- $C$: vectorial capacity of the vector population
  - $m$: vectors / hosts ratio
  - $a$: number of hosts bitten mosquito$^{-1}$ day$^{-1}$ (aggressivity)
  - $p$: daily survival rate for mosquitoes
  - $n$: length of extrinsic cycle (days)
- $b$: vector competence, i.e. proportion of infecting bites
- $r$: host recovery rate (day$^{-1}$)
Possible effects of climate changes on $R_0$

- Minor effects
  - Vector competence $b$: possibly influenced by temperature

Hypothetic interactions between genetic factors and temperature (Tabachnick, 2003)
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- **Large expected effects**
  - Vectors / hosts ratio: abundance of vectors (and hosts)

Drivers of *Ixodes ricinus* abundance (Medlock et al., 2013)
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  - Aggressivity $a$, survival $p$: temperature and RH

Abortion rate in a tsetse population, Senegal (Bouyer et al., unpubl.)
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Indirect effect of climate changes on health

- Changes in livestock production systems: less cattle, more small ruminants and camels (Seo and Mendelsohn, 2008)

Observed changes in camel populations (Faye et al., 2012)
Indirect effect of climate changes on health

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- “Desertification” → rural exodus → larger cities → Increasing demand on red meat in large cities → intensification of livestock trade

Sheep and goats trade from Somaliland to Saudi Arabia
Indirect effect of climate changes on health

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- Increased risk of transboundary diseases like FMD or PPR

Known emergence of PPR 1942-2009
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Environmental data

We need data with:

- a global coverage, a moderate spatial resolution and a high temporal resolution to model seasonal & annual changes
- long time series to detect & model pluri-annual changes

Rift Valley fever outbreak in northern Mauritania, 2010 (El Mamy et al., 2014) - Rainfall: TAMSAT dataset

[Graph showing rainfall data with RVF outbreak]
Datasets for possible future climates

- IPCC (data distribution center): coarse data provided by the GCM: 300 km resolution
- European ENSEMBLES datasets: finer data provided by RCMs: 25 km resolution
A nice resource: http://www.edenextdata.com
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Vectors

- Africa: a few good datasets: tsetse flies, mosquitoes (malaria, RVF), some tick species
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- Caribbean region: tick *Amblyomma variegatum*
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- Caribbean region: tick *Amblyomma variegatum*
- Europe: mosquitoes (*Aedes albpictus*), ticks (*Ixodes ricinus*), biting midges (*Culicoides imicola*), sandflies: coordinated field studies spanning over 15 years: EDEN / EDENext / Vbornet / Vectornet
Back to *Culicoides* and bluetongue

$R_0$ for BTV transmission by *Culicoides* biting midges Obsoletus group) with 2 different host species - cattle and sheep - playing different epidemiological roles (Guis et al., 2012):

\[
R_0 \propto \frac{b \beta a^2}{\mu} \frac{\nu}{\mu + \nu} \left( \frac{m \phi^2}{r_c + d_c} + \frac{m (1 - \phi)^2}{r_s + d_s} \right)
\]
Future $R_0$ for bluetongue in Europe according to climatic scenarios
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- **Involve stakeholders** (farmers, vets, labs...) for a better appropriation of results: important for sustainability
- **Adopt a multi-disciplinary approach with social sciences and economics**, as from the start of the projects, for at least cost-benefits assessment, and perception studies with respect to diseases and control strategies.
Other changes: tick-borne encephalitis in central and northern Europe

Source: ECDC / Eurostat

Godfrey and Randolph (2011)
Welcome to GERI-2015
Heraklion, 21-23 April 2015


