Local Interactions Select for Lower Pathogen Infectivity

Michael Boots and Michael Mealor, 2007

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Schedule

- **Local Interactions Select for Lower Pathogen Infectivity**
  - Literature and state of the art, theoretical presentations
  - Experiment with larvae, material and methods
  - Results and discussion

- **Social Contacts and Mixing Patterns Relevant to the Spread of Infectious Diseases**
Definitions

- Infectivity: Successful infection of a host → host and neighbour
- Transmissibility: parent → child
- Pathogenicity: potential capacity to cause a disease
- Virulence: degree of pathogenicity → Leads to death
Literature

- Classic theory of parasite evolution: maximizing the epidemiological basic reproductive number $R_0$
- $R_0$ high (close to 1), the harder it is to control the infection
- **Assumption**: host populations homogeneously mixed
- Natural host/parasite systems have localized transmission + patchy host distributions $\rightarrow$ spatial structure in host populations can affect the evolution of pathogen infectivity.
- Fixed host populations in most models and regularly spaced
Literature

- Self-shade effect → different evolutionary outcomes

- Homogeneously mixed
Effects of transmissibility of pathogens
Pathogen ability to spread far = higher virulence
Mixing host populations + disrupting the spatial restrictions = increased parasite virulence
How does host movement influence pathogen infectivity?
Material and Methods

- Host:
  - Plodia interpunctella larvae
  - «fixed in a food media»
  - Infected larvae do NOT grow

- Pathogen:
  - Specific granulosis virus (PiGV) → oral uptake
  - Minor effect on host population dynamics
  - Established within the larvae
Material and Methods

- Level 1: Soft food media
  - loose/homogeneous pathogen distribution
- Level 2: Intermediate food media
  - Slightly patchy host distribution
- Level 3: Hard food media
  - patchy host distribution
  - PiGV transmission localized
- Controll: geographical constraints in soft food media
Material and Methods

- Duration of experiments: 40 weeks = 8 generations of larvae/moths
- Only larval movement affected, adults still mixing
- Infectivity established by infecting original stock: between 147 and 200 larvae were exposed to the virus
- Infectivity calculated by dividing percentage of mortality by number of virions present within extracted solution (distructively sampled larvae)
Results: influence of viscosity on distance travelled

Soft medium: great dispersal distance, faster movements

Hard medium: short dispersal distance

(P < 0.01)
Results: influence of viscosity on infectivity

Clear effect of viscosity on infectivity
(P < 0.01)

Hard food medium, virus became less infective
→ Evidence for selection for lower infectivity in populations with the lowest movement rates: evolutionary process

No significance between L1 and L2
→ Selection pressure not strong enough, nonlinear effect
Results

- No effect of viscosity on larvae performance
  - Larvae development time (P = 0.79)
  - Pupal weight (P = 0.8)

- No significant difference in concentration of virions extracted: no evidence of maladaptation

- Genetic drifts of the viruses are unlikely

- Hard food media: more localized transmission → self-shading, evolution towards lower infectivity
Discussion and conclusion

- Spatial structure crucial to evolutionary outcomes of viruses
- Selection pressure will be altered by movements, connectivity, globalization…
- Increase in the extent of disease outbreaks and also emergence of more infective strains

- Difficult to evaluate evolution of pathogens in a human context
- Need for more manipulative experiments to test these predictions

- Question: what can affect the spread of infectious diseases in human populations? How can we evaluate those parameters?
Second article:

Social Contacts and Mixing Patterns Relevant to the Spread of Infectious Diseases

Mossong J. et. al
Abundance of mathematical models for infectious diseases transmission and propagation

Here: case of diseases transmitted by respiratory droplets or close-contact route.

Contact structure assumed to follow predetermined pattern governed by small number of parameters, no empirical studies

First, large-scale population-based survey of epidemiologically relevant social contact patterns

Assess how an emerging infection could spread in a wholly susceptible populations
Material and Methods

- Paper diary to record contact from 05:00 to 05:00 the following morning:
  - Intensity of contact (physical, non physical)
  - location
  - Duration spent together
  - frequency of contact with same individual.

- Surveys from 05.2005 to 09.2016 in 8 European countries (BE, D, FI, GB, I, LU, NL, and PL)

- Participants: broadly representative for population in terms of age, gender, (deliberate oversampling of Children and adolescents)
Results

- Total of 7290 diaries (from 267 in NL to 1328 in DE)
- 97904 contacts recorded
- Fewest number of contacts: DE, highest number of contacts: I

- Consistent pattern of contact frequency by age: gradual rise in number of contacts between children, peak among 10 to 19 y-olds, then decrease to lower plateau in adults until 50 and sharp decrease.
Results in frequency, intensity and location of contacts

Duration

Frequency

Location

Correlation between duration and frequency
Results

- High degree of correlation between physical contact and intimacy → use physical contacts as a proxy measure for high-intensity contacts.
- More than half of all contacts occurred at home, work, or at school.

Physical contacts only
Results: age-related mixing patterns
- Individuals in all age groups tend to mix with others of similar age
- Children mixing with adults and vice versa
- Adults mixing with other adults, mainly non-physical, at work
Results: simulated initial phase of an Epidemic

All contacts

Physical contacts only

![Graph A](image1.png)

![Graph B](image2.png)
Discussion and conclusion

- „Hard facts“ about mixing pattern

- **Key assumptions:**
  - Talking and/or touching with other individuals constitutes main at risk event
  - Neglected: being in confined space / close physical proximity with each other

- Further studies needed → which contact pattern (physical / non physical) needed for which disease
Discussion and conclusion

- Validation of self-recorded contact pattern by using different approach
  - e.g. interview or observations (∴ expensive)

- Uniformity of methodology not 100% given → different companies involved

- Nevertheless: Results shown are important