Variation in the rate and pattern of spread in introduced species and its implications

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Variation of rates within species
*Drosophila subobscura*, the commonest European dros, in the Americas

Introduced ca 1978, full N-S range by 1982. Spread > 850 km/yr N-S, ca 85 W-E
The spread of the Africanised honey bee in South and Central America.

Spread rates:
- About 185 km/year NW
- About 85 km/year SW

*Figure 6.2* Map of the spread of the Africanized honey bee, *Apis mellifera*. The contours are at 5-year intervals, and are in places interpolated. (Compiled from several sources; illustration by Mike Hill.)
Native red squirrel
Sciurus vulgaris

Introduced American grey squirrel
Sciurus carolinensis

from Yalden D 1999
The history of British mammals (Poyser)

1920 1945 1970 1990

7.7 km yr\(^{-1}\) in East Anglia, 0 at the River Tees
Some variations in rates kilometres per year

Rabbits *Oryctolagus cuniculus*

- Britain, medieval: 1-2
- New Zealand: \( \leq 16 \)
- Australia, east & south: 15
  - Nullarbor Plain: 100
  - Murray-Darling: 125
  - Northern Territories: 270-390

Himalayan balsam *Impatiens glandulifera*

- Czech Republic, 4 river tributuries: 0, 0.0083, 0.0204, 0.0310
  - grid mapping records: 3.66
- Britain, nearest hectads: 1920-40: 1.9, 1940-60: 3-5
  - cumulative hectad records: 3.86
  - vice-county records: initial: 2.6, maximum: 38
Rate of spread of cane toads in Australia
Variation

in patterns and rates

between species
Post-glacial spread rates for trees from pollen data per year:

Note that per generation rates are at least an order of magnitude greater.
Spread rates for various plants

data from Table 1 of the Pyšek and Hulme review,
2005 Ecoscience 12 (3) pp. 306-7
Veronica filiformis in the British Isles

8.7 kms per year

Distribution 1999
Harmonia axyridis  Harlequin ladybird

spreading at ca. 70 kilometres a year
Impatiens glandulifera

Three species with logistic spread, no lag

Lags can not be identified in arithmetic plots

<table>
<thead>
<tr>
<th>Species</th>
<th>Initial</th>
<th>Maximum</th>
<th>Kms per year</th>
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</thead>
<tbody>
<tr>
<td>I. glandulifera</td>
<td>2.6</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>I. parviflora</td>
<td>1.6</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>I. capensis</td>
<td>1.4</td>
<td>13</td>
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</table>
A study of the variation in rates shown by two British hectad surveys.

Only 30 spp here, 118 in the next slides.
1988

1958

square roots

logits

118 species reliably mapped in both surveys
square roots  1988 – 1958  logits
A study of spread rates in three countries over two centuries

<table>
<thead>
<tr>
<th>Area</th>
<th>spp</th>
<th>unit</th>
<th>size</th>
<th>#</th>
<th>area</th>
<th>pop density # / km²</th>
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<tbody>
<tr>
<td>CZ</td>
<td>63</td>
<td>map. pole 10' x 6'</td>
<td>133</td>
<td>679</td>
<td>79</td>
<td>130</td>
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<tr>
<td>Britain</td>
<td>7</td>
<td>hectad</td>
<td>100</td>
<td>2837</td>
<td>229</td>
<td>235</td>
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<tr>
<td>Ireland</td>
<td>4</td>
<td>hectad</td>
<td>100</td>
<td>1007</td>
<td>84</td>
<td>60</td>
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</table>

From Williamson, Pyšek, Jarošík & Prach 2005 Ecoscience 12, 424 - 433
52 sp./place records are straight on sqrt plots (ripple spread, maybe)

sqrt (km/year) is normally distributed over spp.
36 sp./place records are straight on log plots (jump spread, maybe)

log(doubling time) is normally distributed over spp.
10 Czech spp. are straight on arithmetic plots

All plots are cumulative and this pattern comes in casual spp.
3 Czech spp. are not straight on any plot
### Summary of Czech shapes

<table>
<thead>
<tr>
<th></th>
<th>log</th>
<th>log→sqrt</th>
<th>sqrt/log</th>
<th>sqrt</th>
<th>Σ</th>
<th>arith</th>
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<tbody>
<tr>
<td>ALL</td>
<td>12</td>
<td>6</td>
<td>12</td>
<td>20</td>
<td>50</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>bend</td>
<td>9</td>
<td>0</td>
<td>5</td>
<td>8</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lag</td>
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<td>1</td>
<td>4</td>
<td>8</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>neither</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Circles are sqrt/log, diamonds are log to sqrt
'log' spp. only
Rates from foci proportional to area

'sqrt' spp. only
Lag in years: 1st record to start of systematic increase

Lag times in years:
- minimum: 7
- median: 41
- Maximum: 154
Conclusions from the three country study:

1) almost all species have plots that are straight in part on some transformation

2) the rate of spread is almost always faster than expected from known dispersal and probably a result of human activity rather than simple biology

3) straight square root plots are commoner than straight logarithmic ones, implying that steady, if fast, spread is more common than jumps, though both are important

4) lags occur in over half the species and can be quite long
How long, on average, does it take an alien to fill its range?
A four country study of the effect of time since first record, “residence time” on the range of alien plant species.

Box and whisker plots of the logits of current ranges in Ireland, Britain, Germany, and Czech Republic.
Logits vs. time

A lowess plot for Britain only

Overlain regressions for all four countries

Residence time accounts for about 10% of the variance in range size
Native and neophyte range means converge

all other regressions and RMAs  Regressions  Ireland  Britain

150  250  350

Years ago
Implications and Conclusions

Fast spreading species are spectacular and usually impossible to eliminate in large areas

so management by control, adaptation and mitigation

Many species spread slowly and/or have long lag periods

so there is need to identify future problem species and take action before they spread far
Many thanks to my co-authors of three spread and residence time papers:

Mark Telfer, Jane Stout, Petr Pyšek, Chris Preston, Karel Prach, Ann Milbau, Ingolf Kühn, Stefan Klotz, Vojtěch Jarošík, Mark Hill, Katharina Dehnen-Schmutz