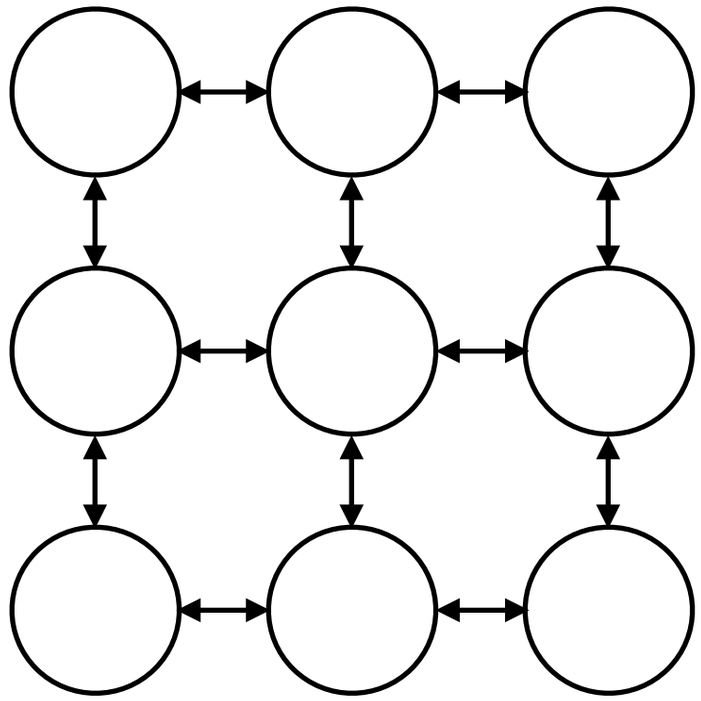
Spatial dynamics: simulations & data

Austin Burt
Imperial College London

Simulation model of driving Y

- Discrete generations
- Stepping-stone array of islands, equal dispersal to all 4 neighbours, edges are absorbing
- Density-independent and -dependent (Deredec) survival to adulthood within islands
- Stochastic:

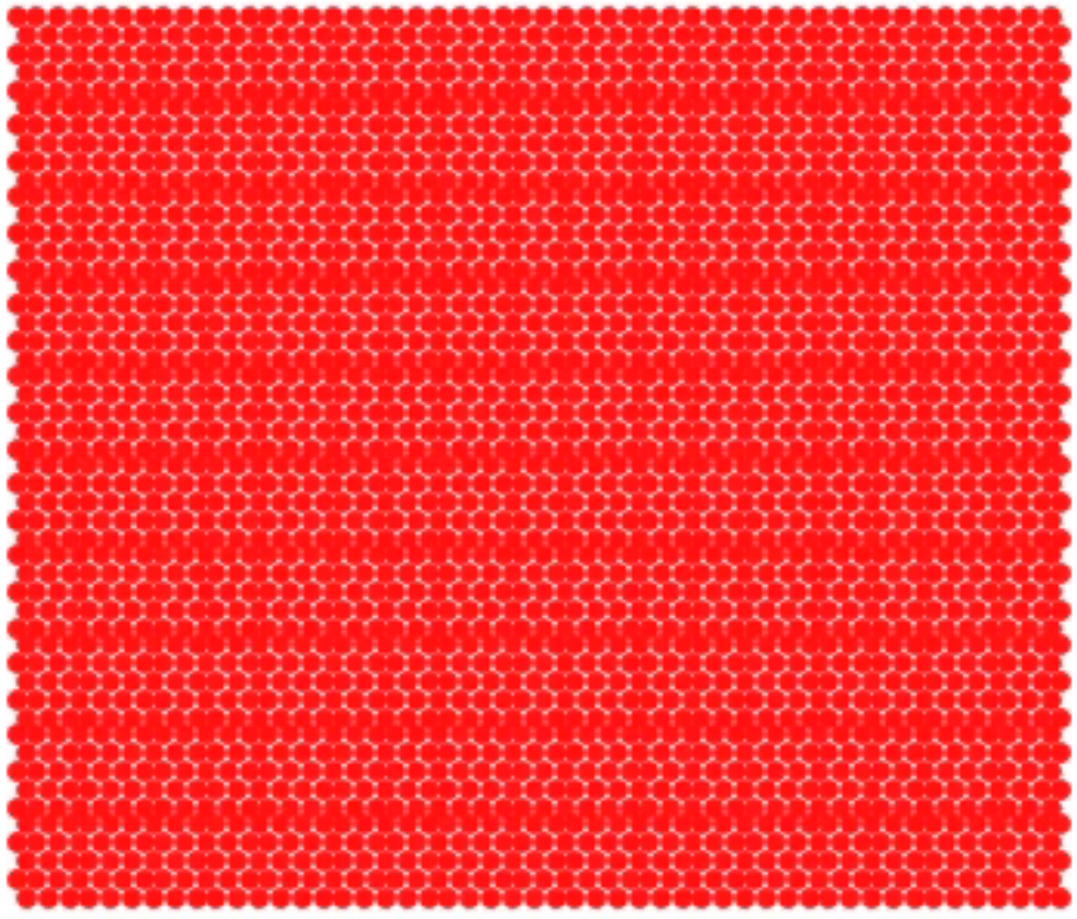


Survival to adulthood	Binomial
Mating	Binomial
Dispersal	Multinomial
Fecundity	Poisson

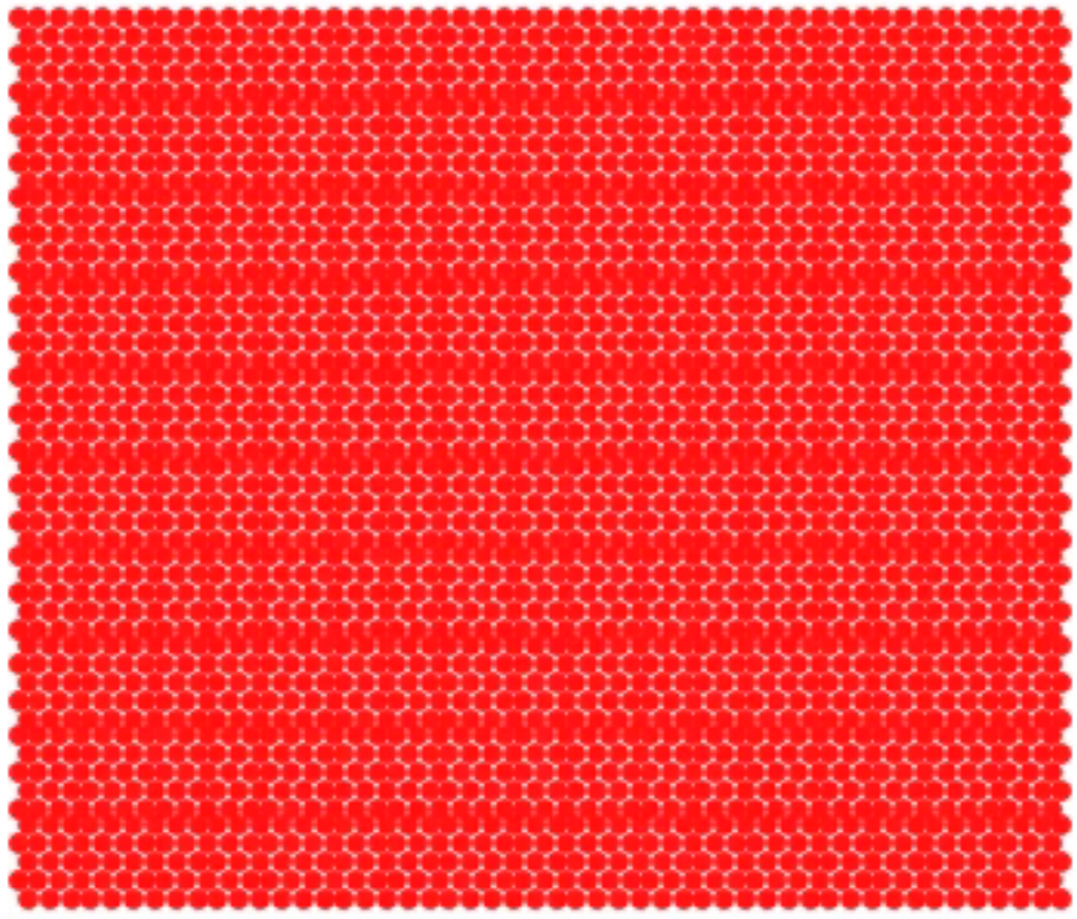
Simulation model of driving Y

- 50 x 50 grid (2500 islands)
- 50 HEG-bearing males introduced into 10 randomly chosen islands

m=0.85 [16]



m=0.95 [11]

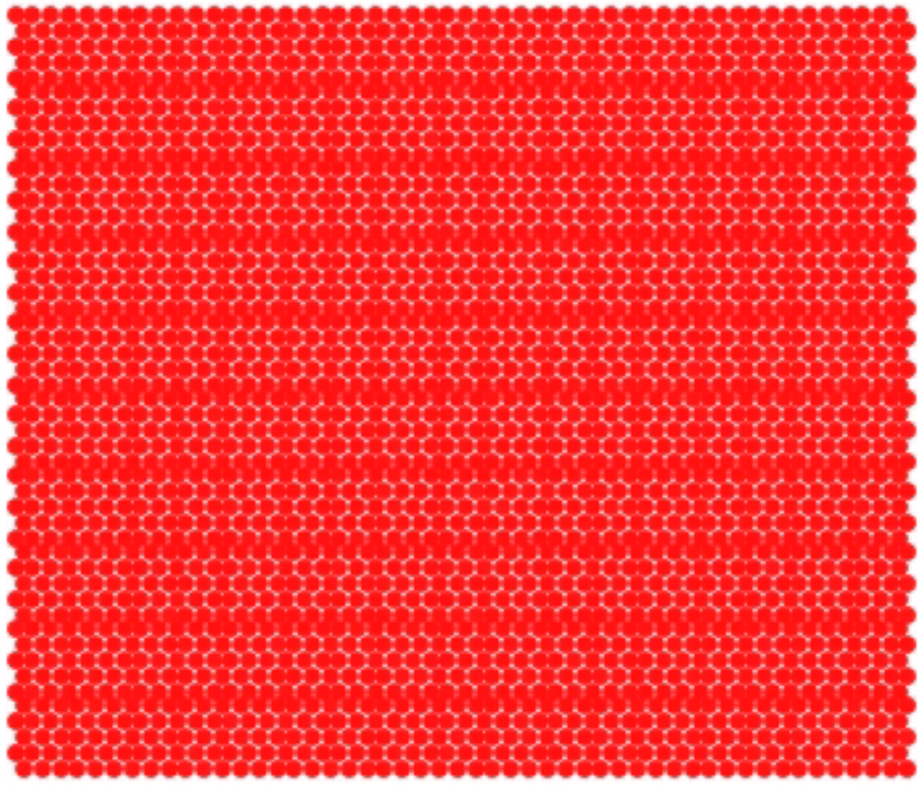


Baseline parameter values

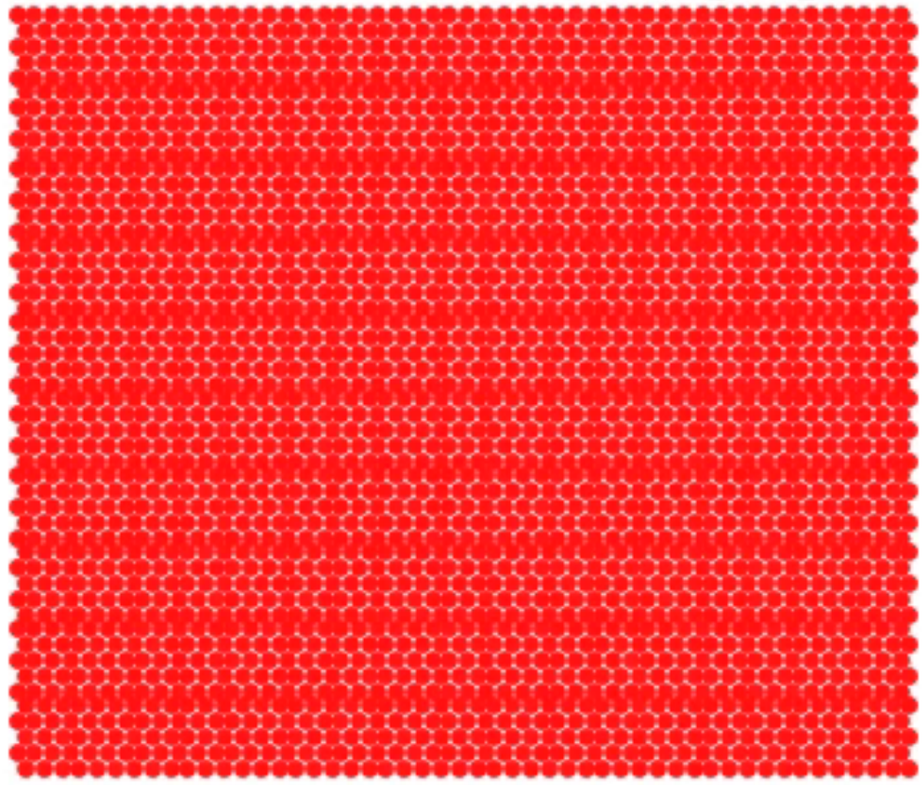
Juvenile mortality (u_j)	$0.168da^{-1}$	Density-dependent param. (a)	10^6
Length of juvenile stage (T_j)	16da	Emigration rate (u)	$0.01gen^{-1}$
Fecundity (f)	$200gen^{-1}$	$R_m = (1-u_j)^{T_j} f / 2 = 5.3$	$m_{crit} = 1-1/(2R_m) = 0.91$

HEG-free equilibrium:
$a(R_m-1)$ = 4.3M zygotes
(43K adults)

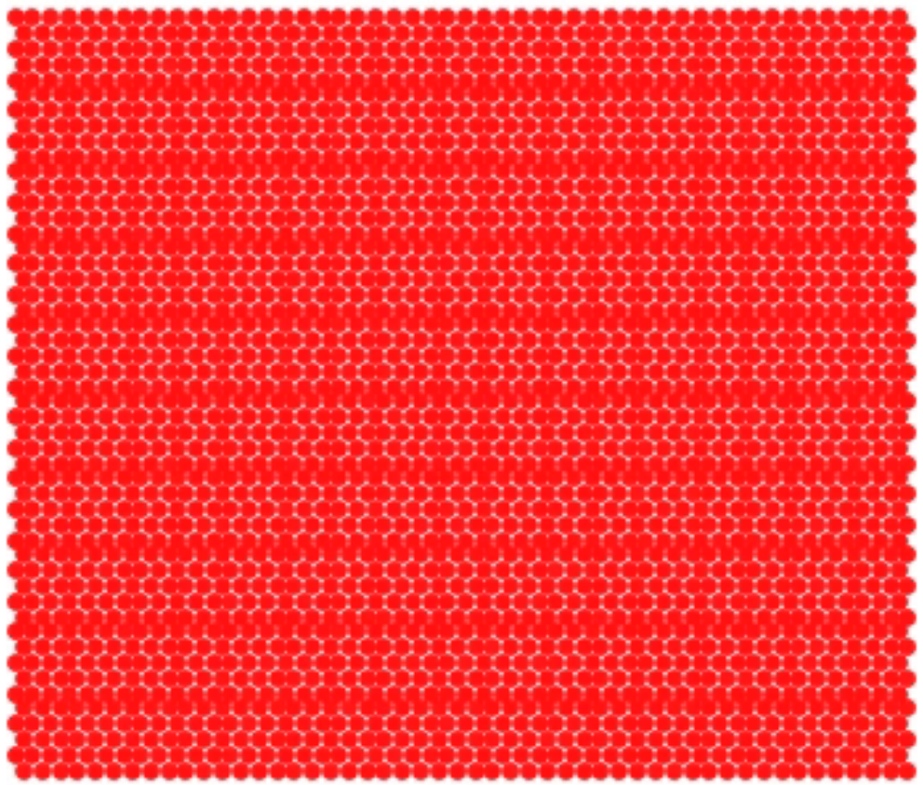
m=0.999 [12]



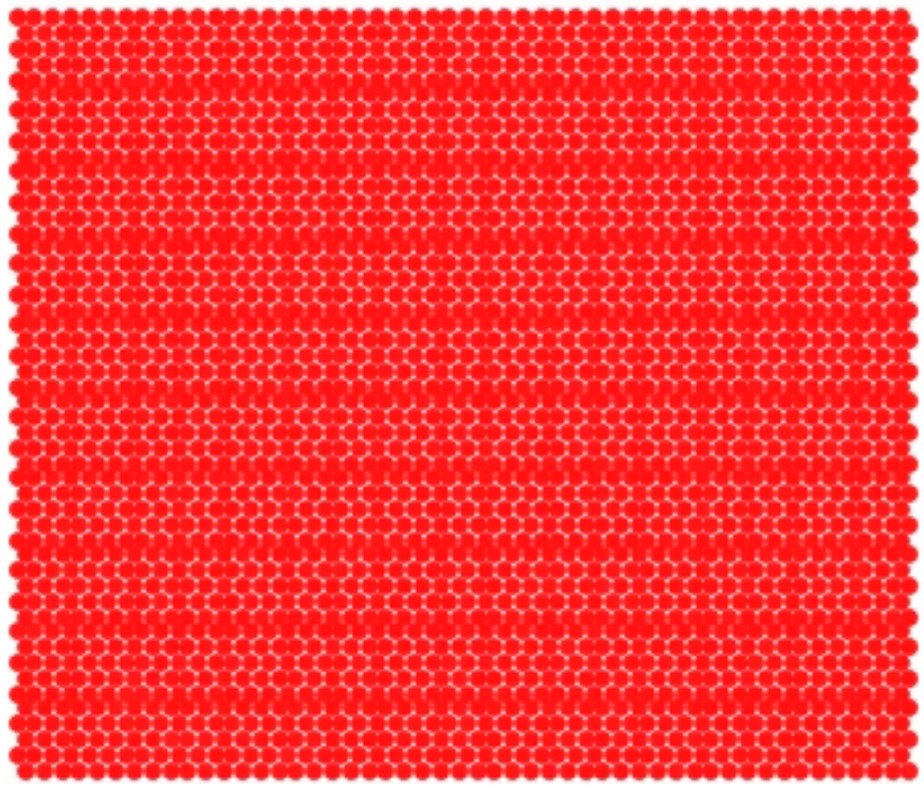
Allee effect (θ=100) [14]



500 release sites once [13]



500 release sites ea. 6 mo [15]

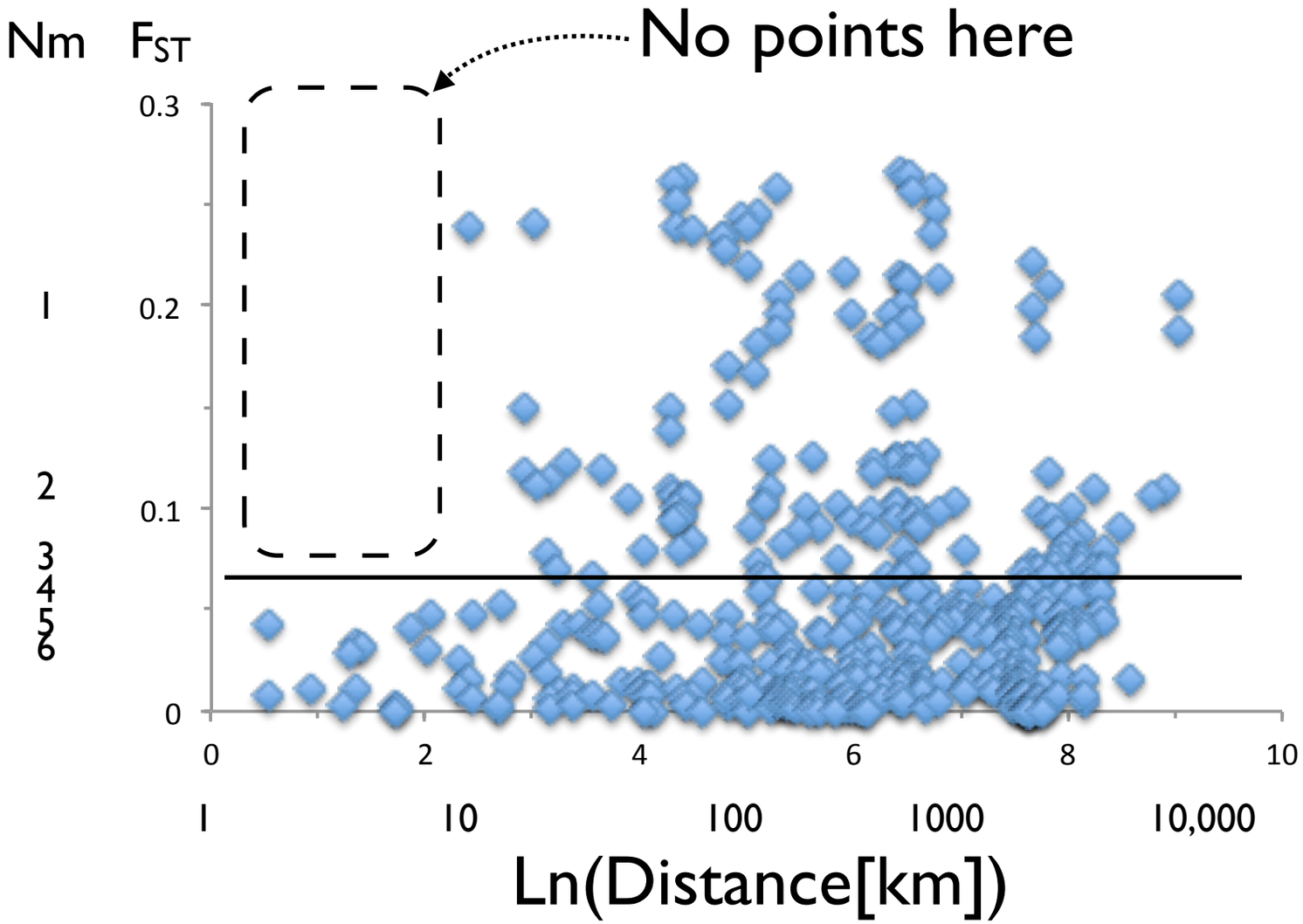


Not included

- No spatial, temporal heterogeneity in R_m (favourable & unfavourable habitats, seasonality, etc.)
- No spatial, temporal heterogeneity in dispersal (asymmetries, seasonality, long-distance, roads, etc.), life history
- No overlapping generations

Estimates of movement from population differentiation

- Compilation of studies using microsatellites



- 485 estimates from ~17 studies of *An. gambiae s.l.*
- Intercept ~ 0.06; corresponds to Nm ~ 4
- Needs full error-checking & analysis

A. Beaghton, C. Meghir, I. Lysenko

Estimates of movement from population differentiation

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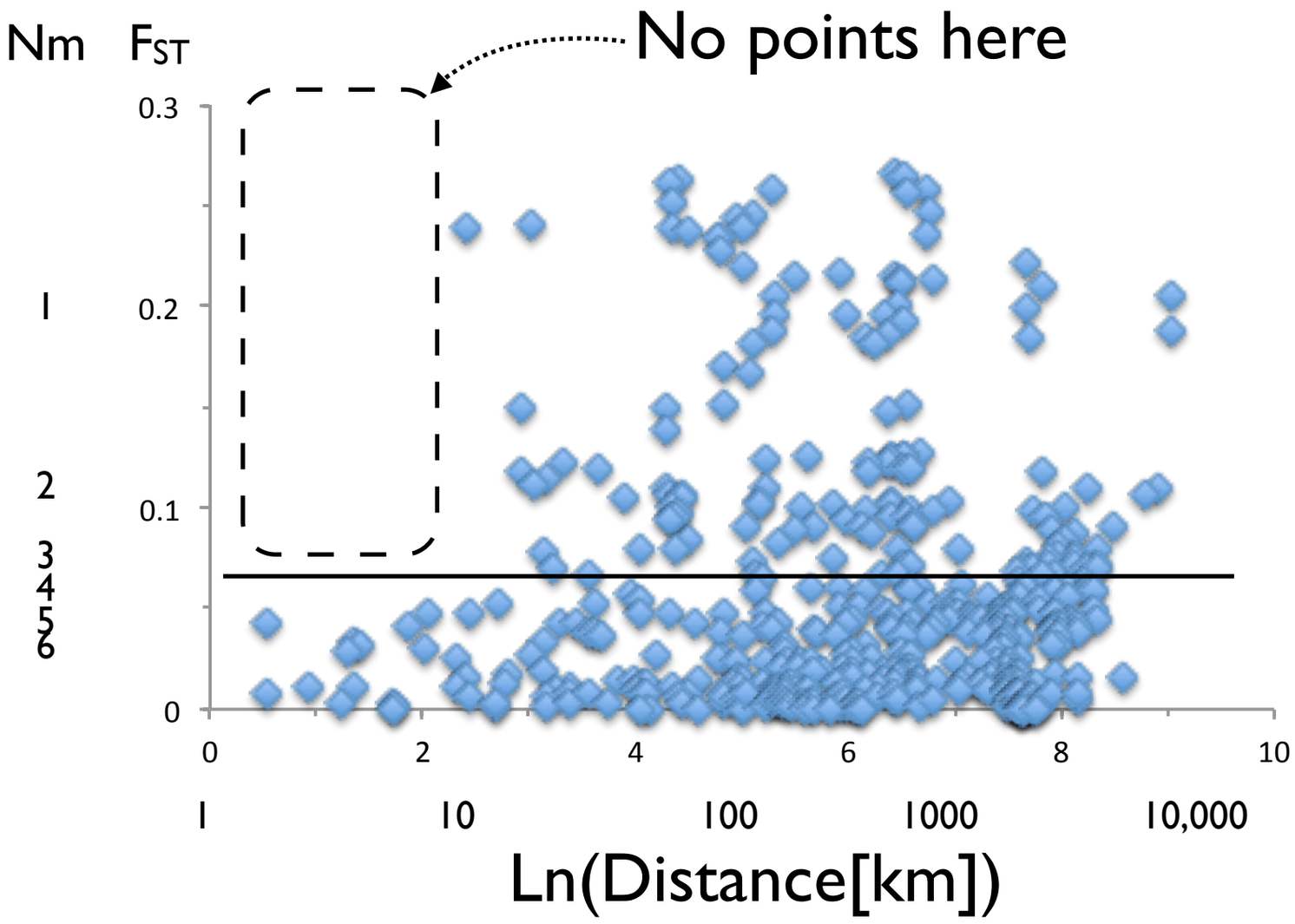
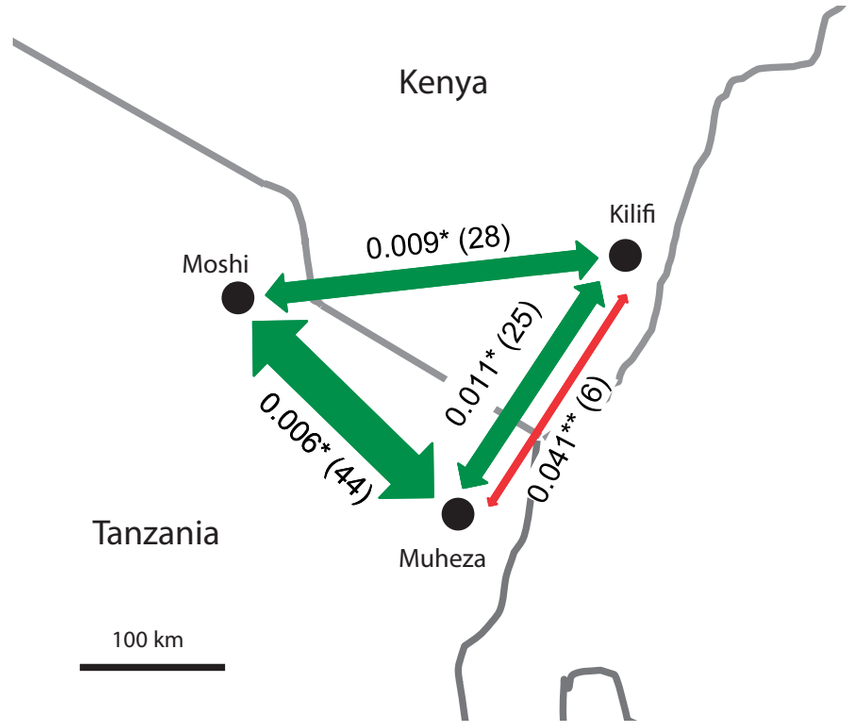


Genomics will add new data



O'Loughlin et al. 2014

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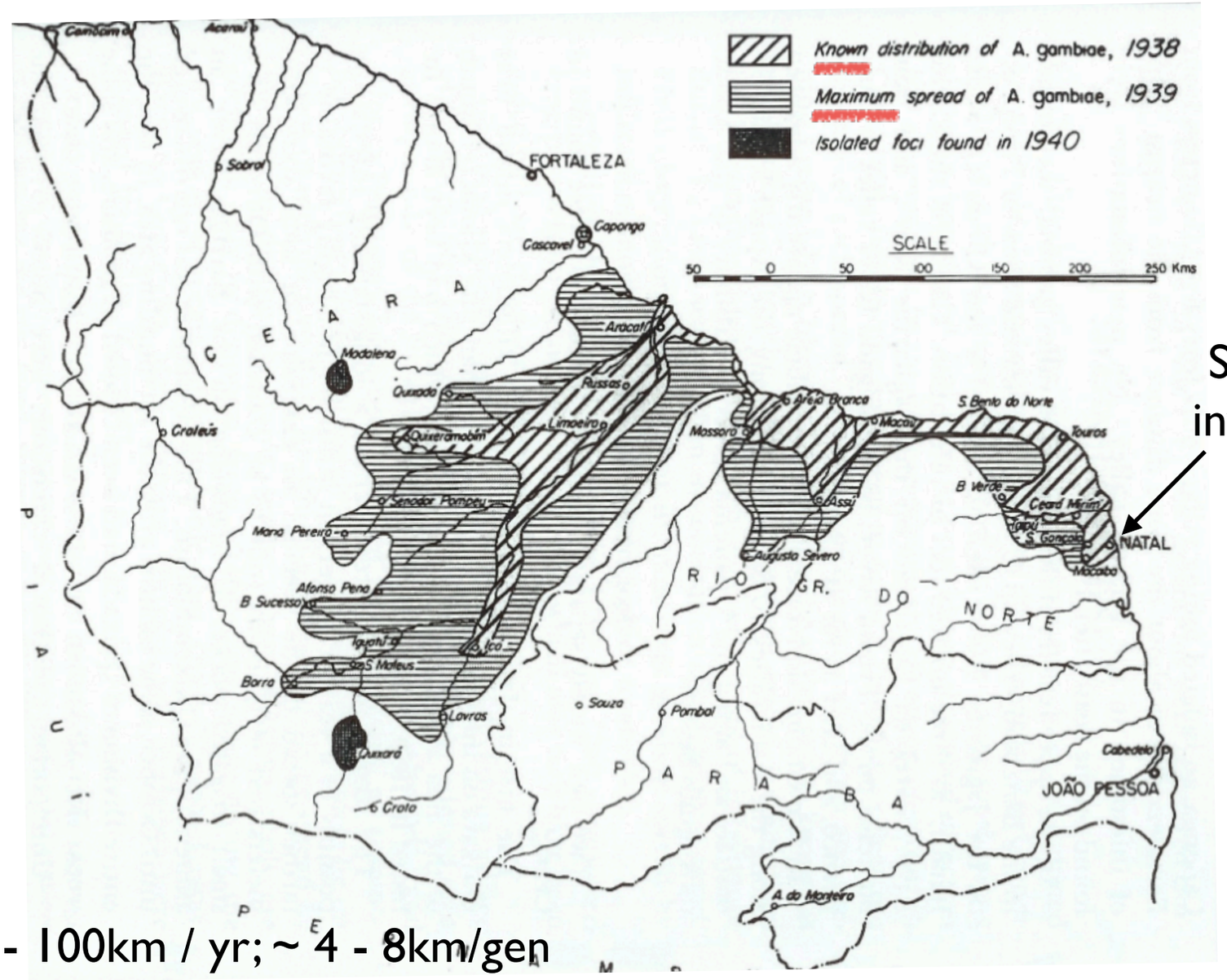
Parameterization (1)

An. arabiensis



Site of invasion 1930

- Speed of species invasion ~ 50 - 100km / yr; ~ 4 - 8km/gen
- No invasion into unsuitable habitat
- Inferred mechanisms:
  - Wind possibly important in preventing movement south from Natal
  - Several 'long jumps' most probably by boat, train or automobile

Quick-and-dirty analysis:

$4 = 2\sqrt{(DR_m)} = 2\sqrt{(10D)}$

$D \sim 0.4 km^2/gen$

$\sigma = \sqrt{(2D)} \sim 0.9 km/gen$

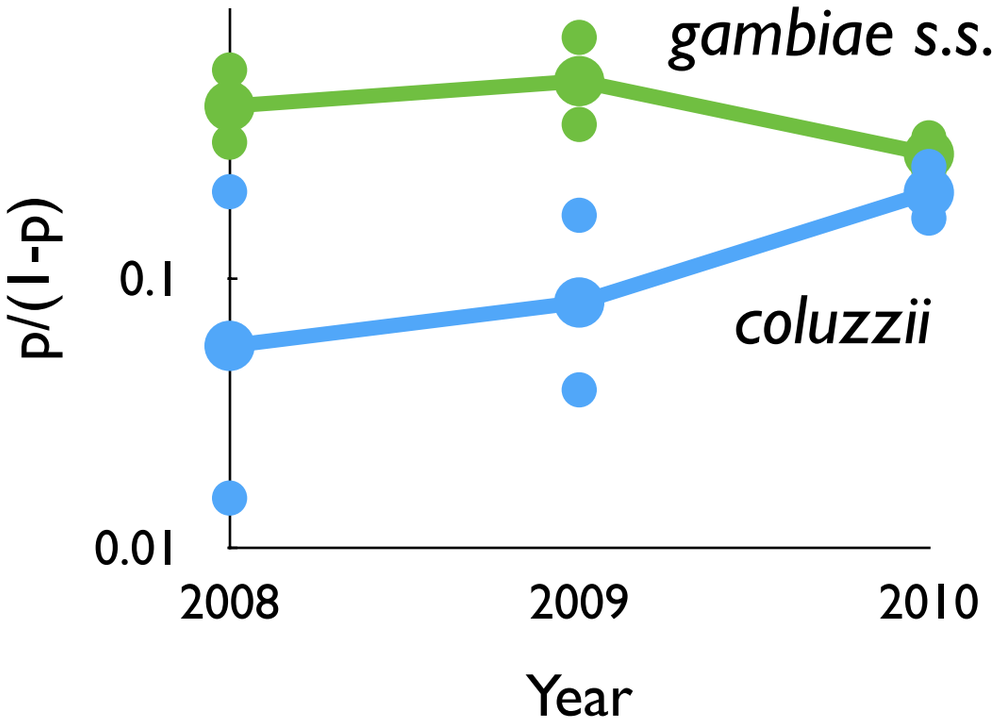
Parameterization (2)

Spread of insecticide resistance: *N1575Y* mutation in voltage-gated sodium channel:

single recent origin (as judged by haplotype analysis)

found over a range of > 2000km (e.g., 1000km from midpoint)

Frequency in Burkina Faso



Jones et al. 2012 PNAS 109:6614-9

selection coefficient:
s ~ 0.08

Quick-and-dirty analysis:

Suppose spread 1000km in 50 yrs
ie 20km/yr; 1.7km/gen
$1.7 = 2\sqrt{(Ds)} = 2\sqrt{(0.08D)}$
$D \sim 9km^2/gen$
$\sigma = \sqrt{(2D)} = 4km/gen$

Could selection historically have been much stronger (e.g., agricultural use)??
If $s \sim 0.3$, $\sigma \sim 2km/gen$