Dengue Fever and Spatial Spread of Breeding sites

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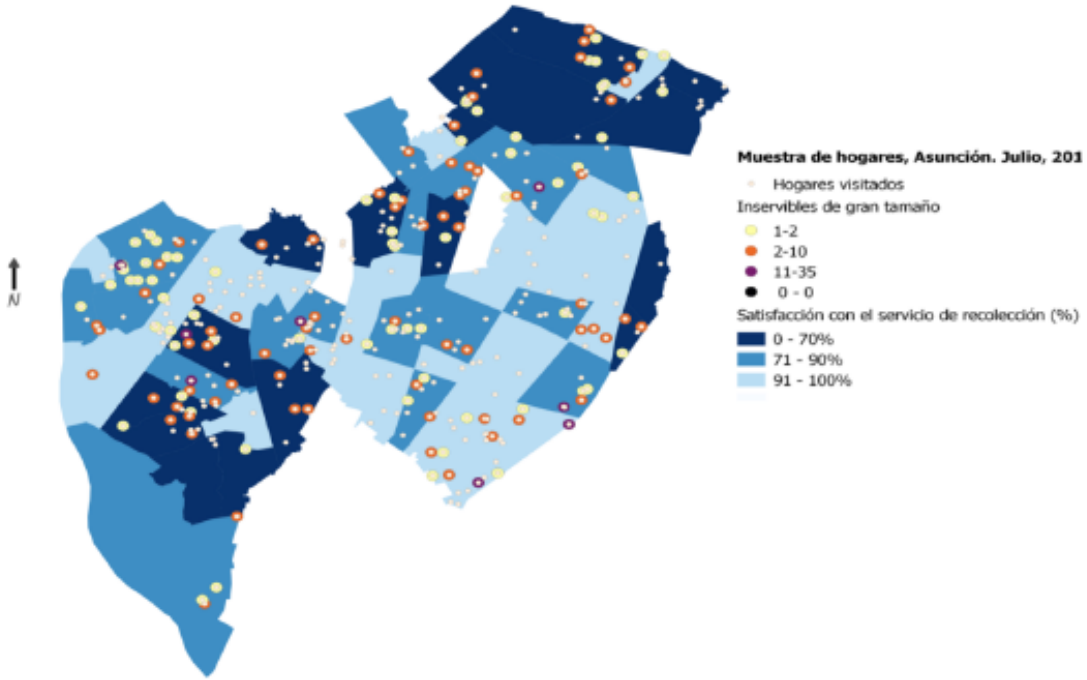

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Starting from a basic ODE model:

$$\dot{E}(t) = aA(t) - m_e E(t) - s_e E(t)$$

$$\dot{L}(x,t) = s_e E(t) - cL^2(t) - m_l L(t) - s_l L(t)$$

$$\dot{A}(t) = s_l L(t) - m_a A(t)$$

K_L = Carrying capacity for larvae

a = fraction of females laying eggs

m_e = mortality of eggs

s_e = switch of eggs to larvae

m_l = mortality of larvae

s_l = switch of larvae to adults

m_a = mortality of adults

Coupling to the infection:

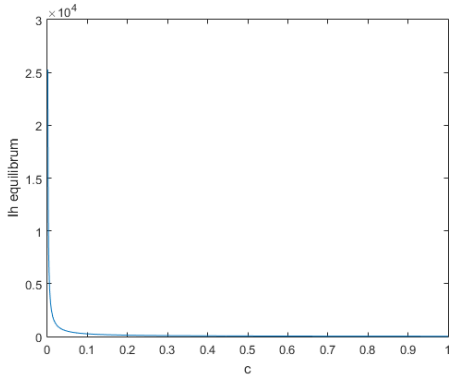
$$\dot{I}_m(t) = \beta I_h(t)(1 - I_m(t)) - s_l \frac{L(t)}{A(t)} I_m(t)$$

$$\dot{I}_h(t) = \beta \frac{A(t)}{N} I_m(t)(1 - I_h(t)) - r I_h(t)$$

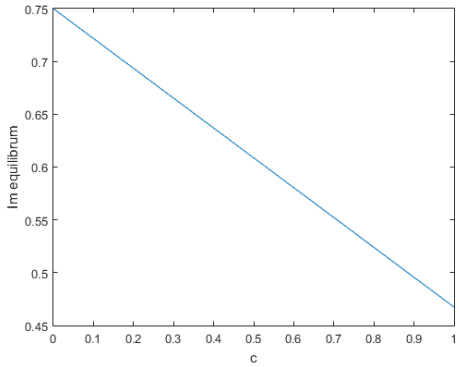
where

$$\begin{aligned} \beta &= \text{ frequency of contacts between SM and IH} \\ m_m &= \text{ mortality of mosquitoes} \\ r &= \text{ recovery rate of humans} \end{aligned}$$

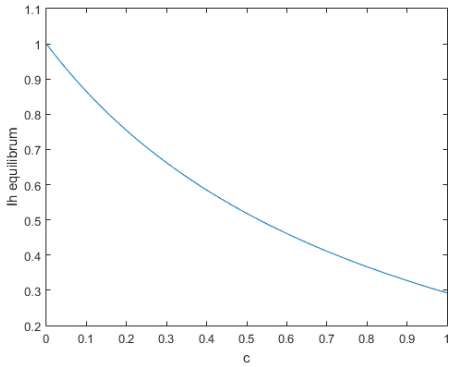
Behaviour of the equilibria as c increases



Adult mosquitos

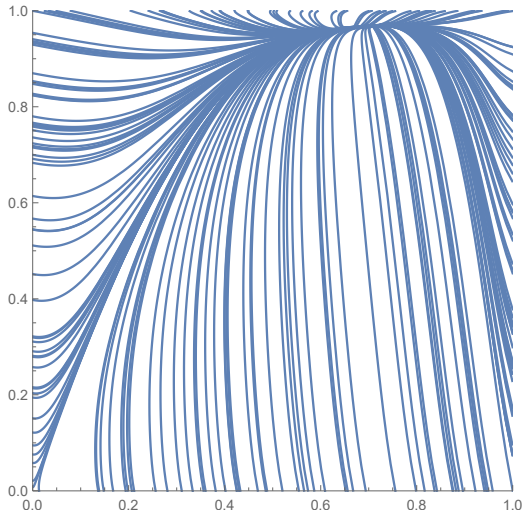


Infected mosquitos

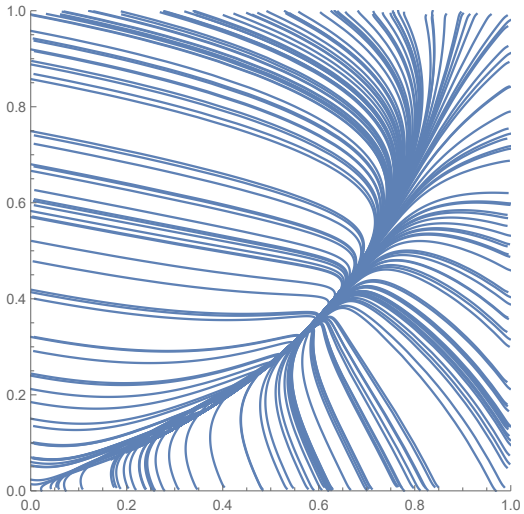


Infected humans

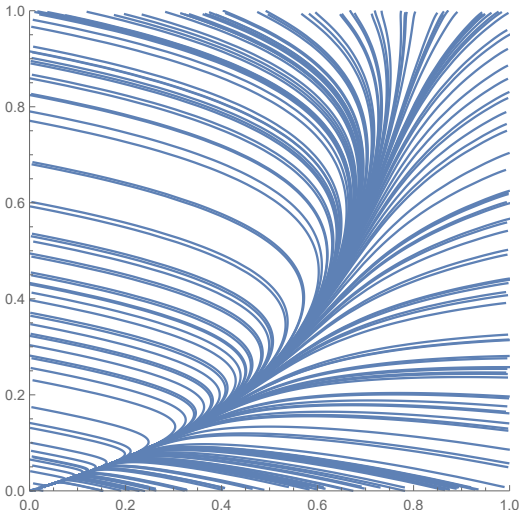
Phase portrait (I_m, I_h)



$c = 0.0125$



$c = 1.5$



$c = 2.5$

Adding spatial dependence:

$$\dot{E}(x,t) = aA(x,t) - m_e E(x,t) - s_e E(x,t)$$

$$\dot{L}(x,t) = s_e E(x,t) - cL^2(x,t) - m_l L(x,t) - s_l L(x,t)$$

$$\dot{A}(x,t) = s_l L(x,t) - m_a A(x,t)$$

$K_L(x) =$ Carrying capacity for larvae

$a =$ fraction of females laying eggs

$m_e =$ mortality of eggs

$s_e =$ switch of eggs to larvae

$m_l =$ mortality of larvae

$s_l =$ switch of larvae to adults

$m_a =$ mortality of adults

Adding spatial dependence:

$$\dot{E}(x,t) = aA(x,t) - m_e E(x,t) - s_e E(x,t)$$

$$\dot{L}(x,t) = s_e E(x,t) - cL^2(x,t) - m_l L(x,t) - s_l L(x,t)$$

$$\dot{A}(x,t) = s_l L(x,t) - m_a A(x,t) + d_m \Delta A(x,t)$$

$K_L(x) =$ Carrying capacity for larvae

$a =$ fraction of females laying eggs

$m_e =$ mortality of eggs

$s_e =$ switch of eggs to larvae

$m_l =$ mortality of larvae

$s_l =$ switch of larvae to adults

$m_a =$ mortality of adults

Coupling to the Infection:

$$\dot{I}_m(x,t) = \beta_{sm-ih} I_H(x,t)\,(1 - I_m(x,t)) - m_m I_m(x,t) + d_m \Delta I_m(x,t)$$

$$\dot{I}_H(x,t) = \beta_{sm-ih} I_m(x,t)\,(1 - I_H(x,t)) - r I_m(x,t)$$

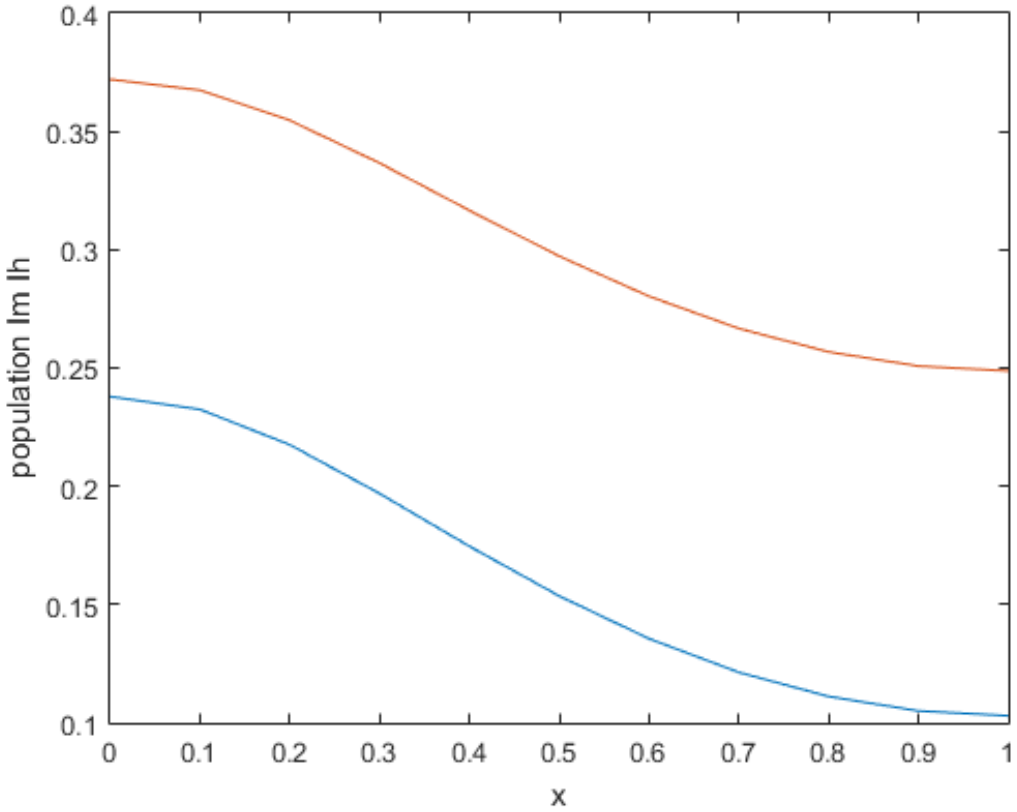
β_{sm-ih} = Frequency of contacts between susceptible mosquitoes and infected humans

m_m = mortality of mosquitoes

d_h = Diffusivity of mosquitoes

r = Recovery rate of humans

Evolution


0.4
0.35
0.3
0.25
0.2
0.15
0.1
population Im Ih
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
x