Impact of **Fecundity-Immunity** Trade-off on Emergent properties and Host Eco-Evolutionary Dynamics.

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Aussois
15.06.2023

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What do we know about epidemics ?

Epidemics are known to reduce the host population size.

But what if the host is evolving /developing defense mechanisms ?

What do we know about epidemics ?

Epidemics propagate → R_0

The basic reproduction number R_0 → R_0 is the number of secondary infections of one infected host in a susceptible population. If $R_0 > 1$, the pathogen can invade and eventually become endemic in the host population.

Host fecundity

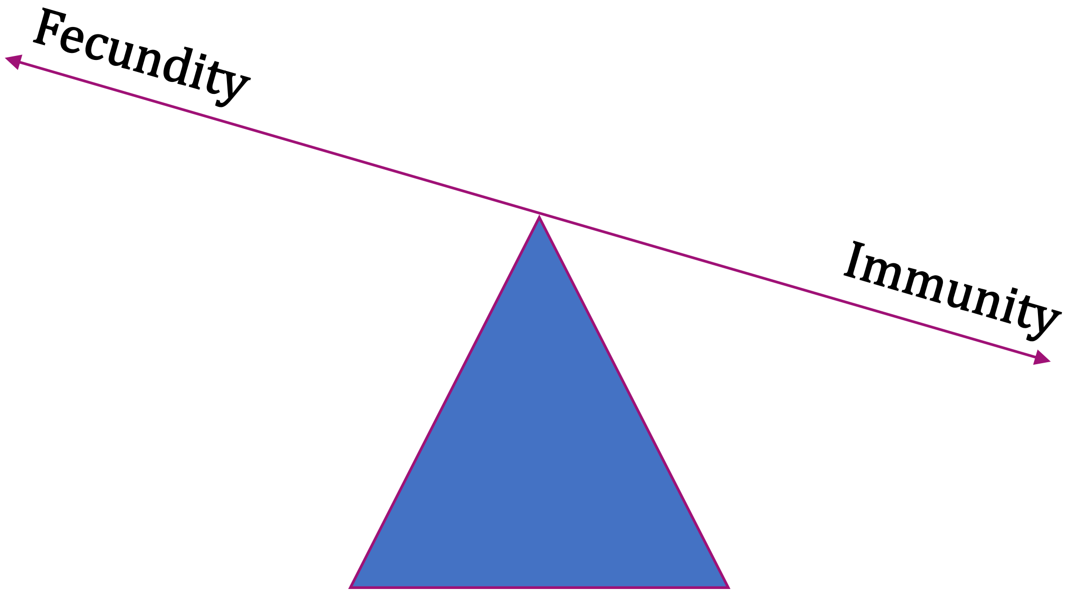
Linked to Host immunity
- Pathogen transmission
- Host recovery
- Pathogen virulence

→ R_0

But what if the host is evolving /enhancing immunity?

Fecundity - Immunity Trade-off

Empirical Evidences



Reproduction–Immunity Trade-Offs in Insects

Robin A. Schwenke[1,2], **Brian P. Lazzaro**[1,2,*], and **Mariana F. Wolfner**[1,3,*,†]
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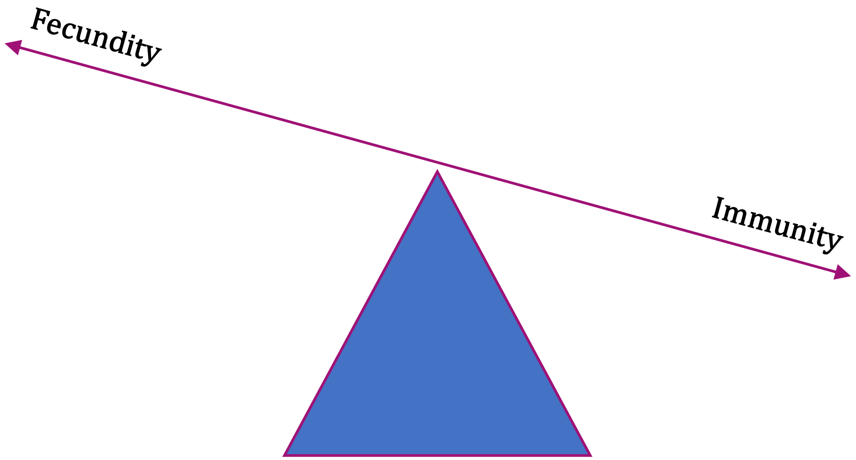
Functional Ecology
British Ecological Society
Functional Ecology 2016, **30**, 1665–1674 doi: 10.1111/1365-2435.12653

Trade-offs among locomotor performance, reproduction and immunity in lizards

Jerry F. Husak[*,1], **Haley A. Ferguson**[1] and **Matthew B. Lovern**[2]
[1]*Department of Biology, University of St. Thomas, St. Paul, Minnesota 55105, USA; and* [2]*Department of Integrative Biology, Oklahoma State University, Stillwater, Oklahoma 74078, USA*

Fecundity - Immunity Trade-off

Theoretical Works



Host – Pathogen Diversification

Host – Pathothen Co – Existence

The Implications of Coevolutionary Dynamics to Host-Parasite Interactions

Alex Best,[1,*] Andy White,[2] and Mike Boots[1]

The Evolution of Host-Parasite Range

A. Best,[1,*] A. White,[2] É. Kisdi,[3] J. Antonovics,[4] M. A. Brockhurst,[5] and M. Boots[1]

The evolution of host resistance: Tolerance and control as distinct strategies

M.R. Miller[a,*], A. White[b], M. Boots[a]

Three Mechanisms of Host Resistance to Microparasites—Avoidance, Recovery and Tolerance—Show Different Evolutionary Dynamics

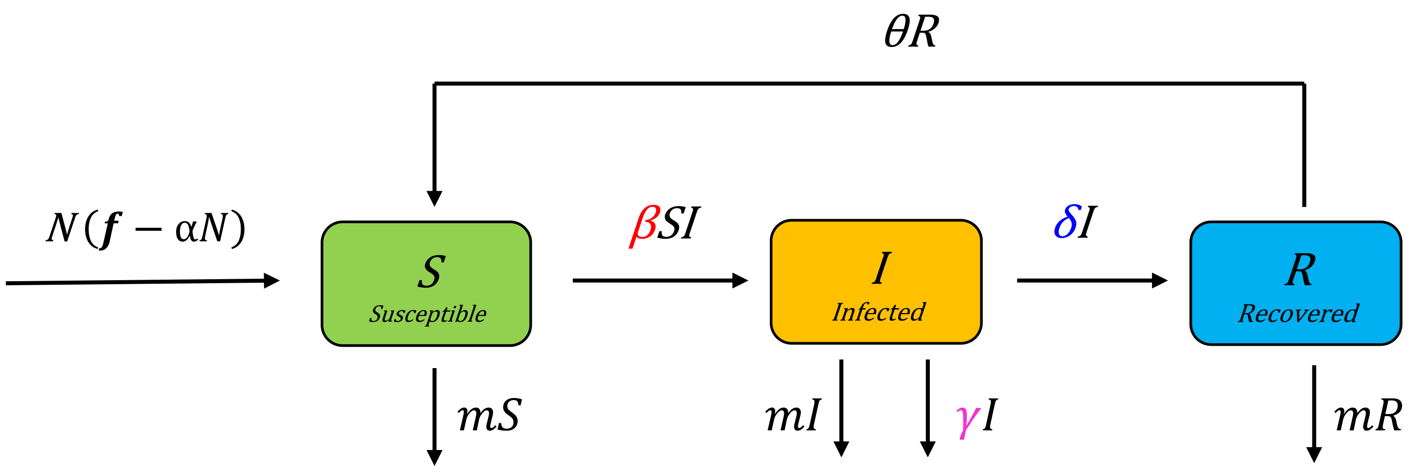
Michael Boots*† and Roger G. Bowers‡

What are the consequences of a **fecundity-immunity** trade-off on emerging properties in the system and on host eco-evolutionary dynamics?

Emerging properties

- Disease propagation R_0
- Total host population density

The epidemic model



$$\frac{dS}{dt} = N(\boldsymbol{f} - \alpha N) - \beta SI - mS + \theta R$$

$$\frac{dI}{dt} = \beta SI - (\gamma + \delta + m)I$$

$$\frac{dR}{dt} = \delta I - (\theta + m)R$$

$$N = S + I + R$$

$\boldsymbol{f}$: ***Fecondity of the species.***

α : *Inter − specific competition of the species.*

β : *Pathogen transmission*

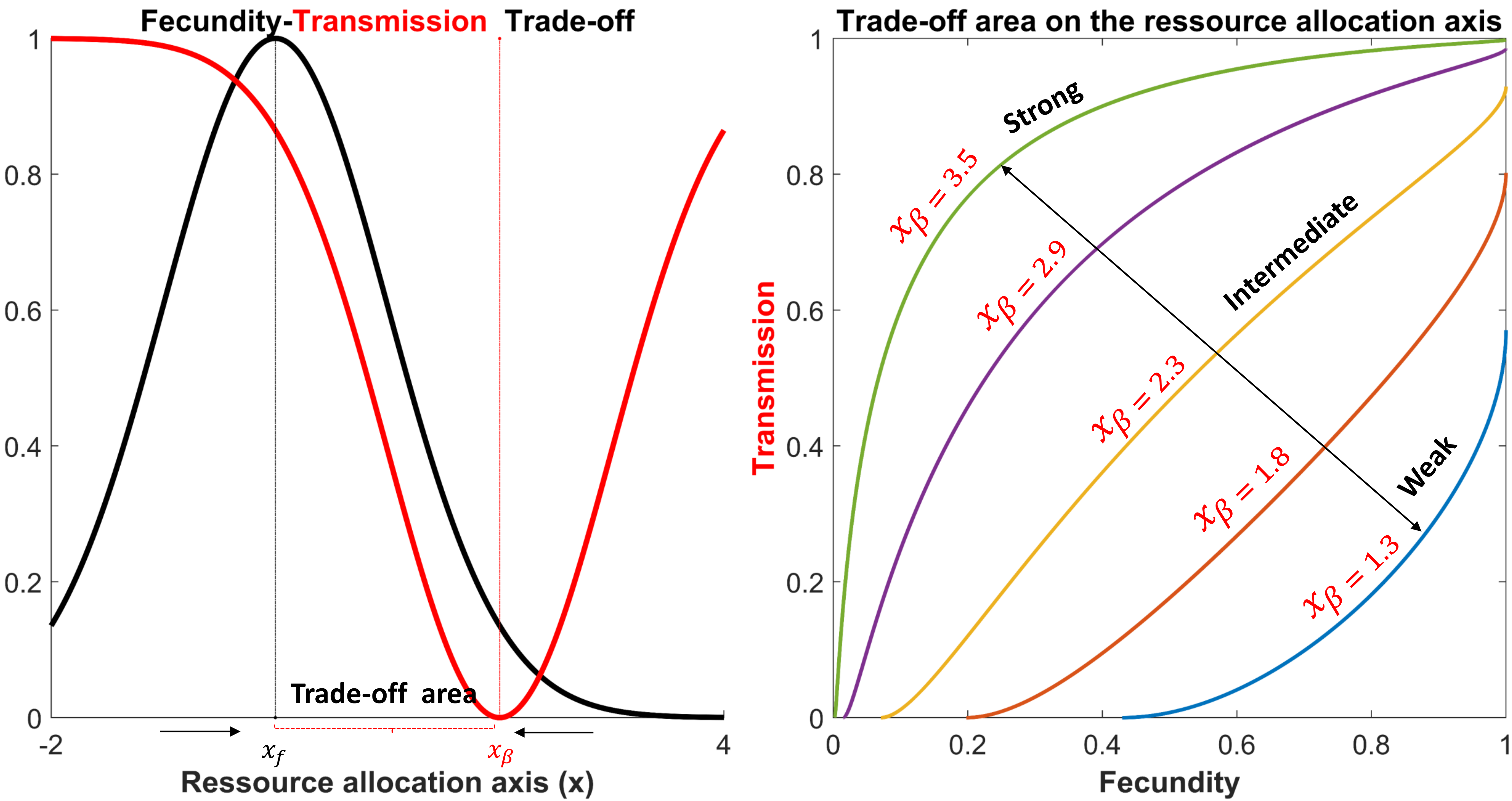
m : *Natural mortality rate.*

γ: *Virulence (Pathogen − induced death rate).*

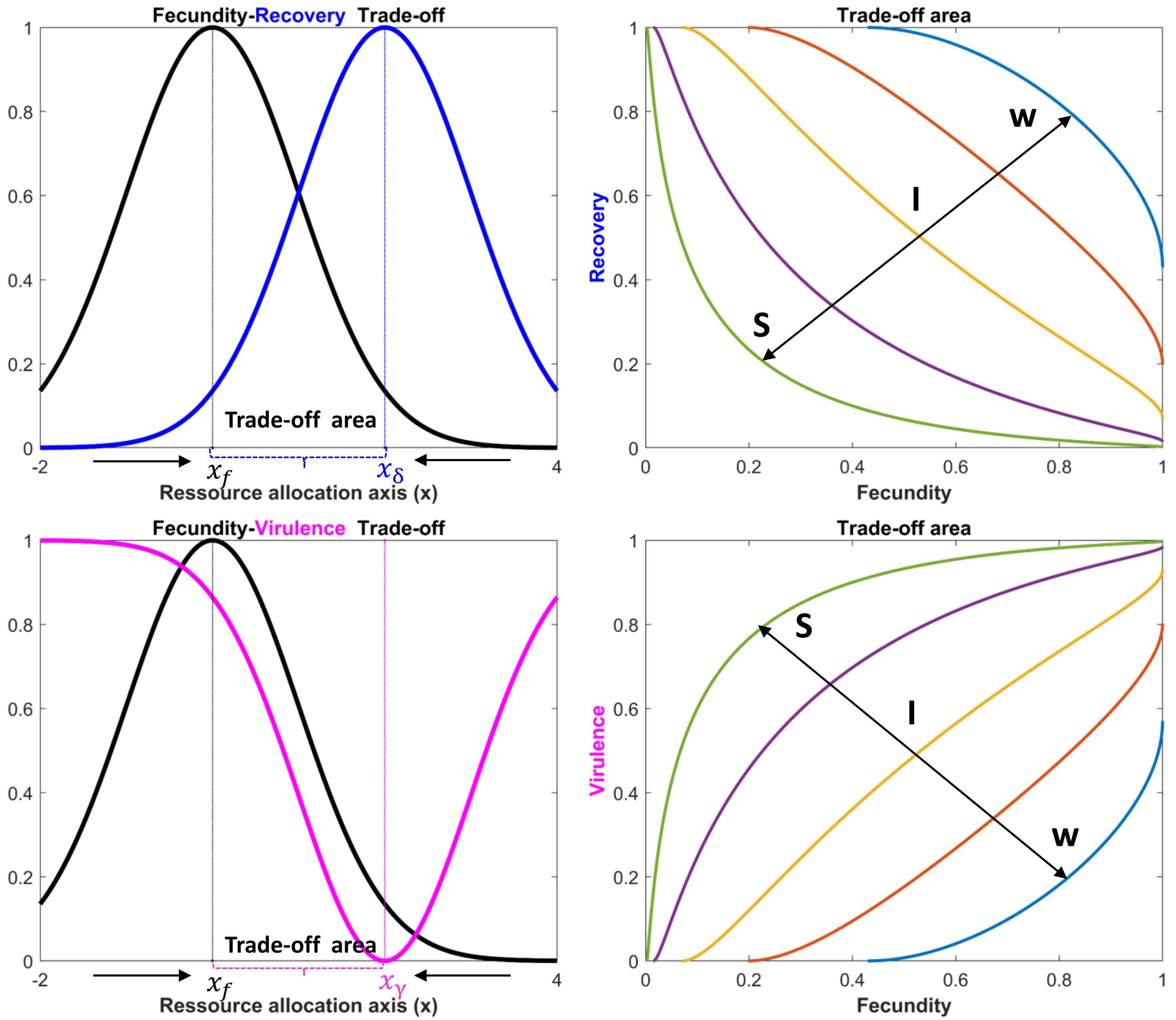
δ : *Recovery rate.*

θ : *Rate of immunity loss*

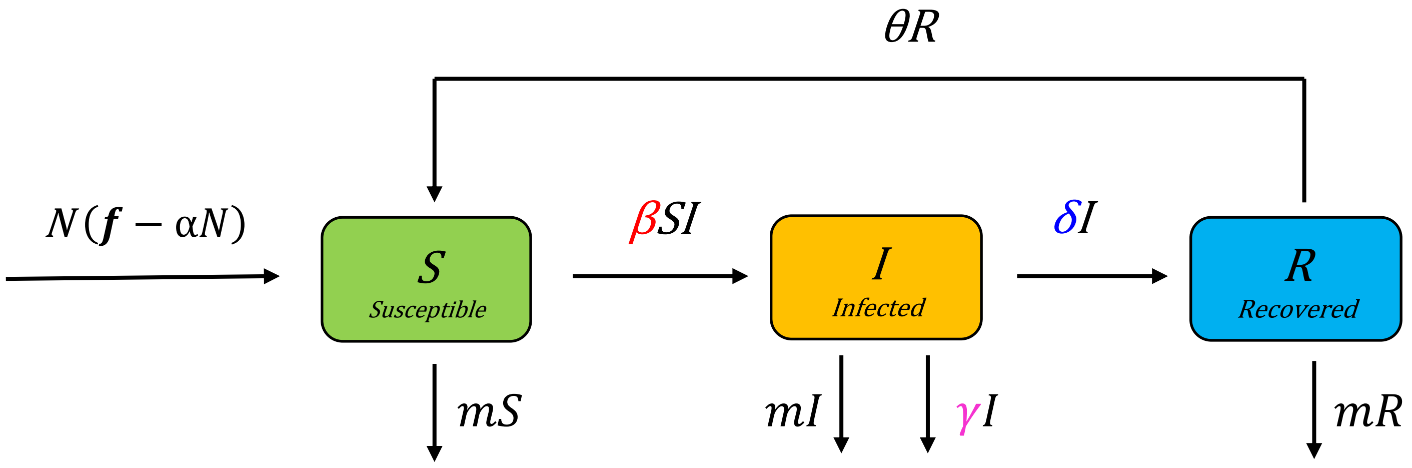
Fecundity - Immunity Trade-off



Fecundity - Immunity Trade-off



The epidemic model



$$\frac{dS}{dt} = N(\boldsymbol{f} - \alpha N) - \beta SI - mS + \theta R$$

$$\frac{dI}{dt} = \beta SI - (\gamma + \delta + m)I$$

$$\frac{dR}{dt} = \delta I - (\theta + m)R$$

$$N = S + I + R$$

$$R_0 = \frac{\beta}{\gamma + \delta + m} * \frac{\boldsymbol{f} - m}{\alpha}$$

$\boldsymbol{f}$: **Fecondity of the species.**

α : Inter − specific competition of the species.

β : Pathogen transmission

m : Natural mortality rate.

γ: Virulence (Pathogen − induced death rate).

δ : Recovery rate.

θ : Rate of immunity loss

Eco – evolutionary dynamics

Adaptive Dynamics

Ecological dynamics – SIR model

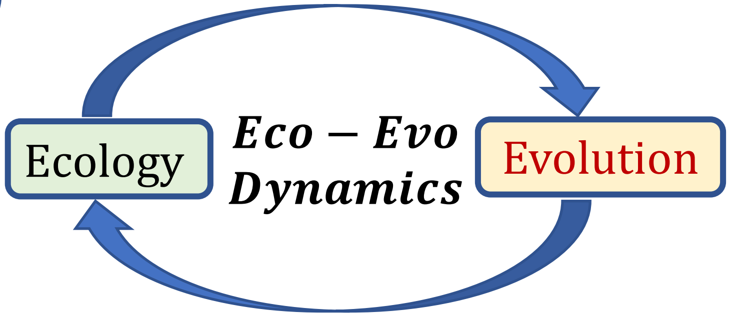
$$\frac{dS}{dt} = N(\boldsymbol{f}(x) - \alpha N) - mS - \beta(x)SI + \theta R$$

$$\frac{dI}{dt} = \beta(x)SI - (\gamma(x) + \delta(x) + m)I$$

$$\frac{dR}{dt} = \delta(x)I - (\theta + m)R$$

Invasion fitness of the rare mutant host x_m in a resident population at Ecological Equilibrium x

$$\boldsymbol{\omega(x_m, x)}$$



1 – *Large population size*

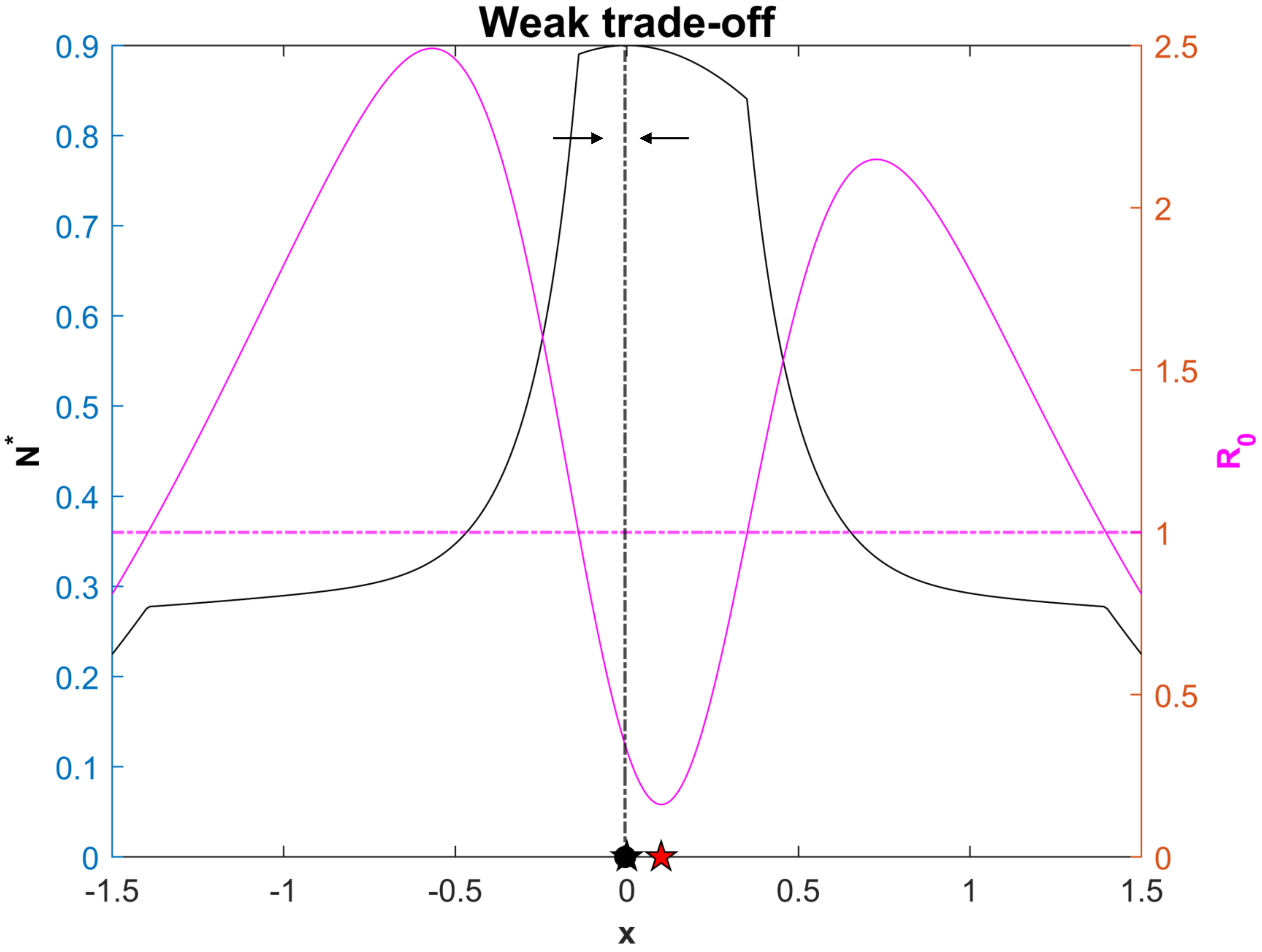
2 – *Clonal reproduction*

3 – *Rareness, randomness, smoothness and small effects of the mutations*

Evolutionary dynamics

$$\frac{dx}{dt} = \frac{1}{2}\mu\,\sigma^2\,N^*(x)\left.\frac{\partial\omega(x_m, x)}{\partial x_m}\right|_{x_m \to\, x}$$

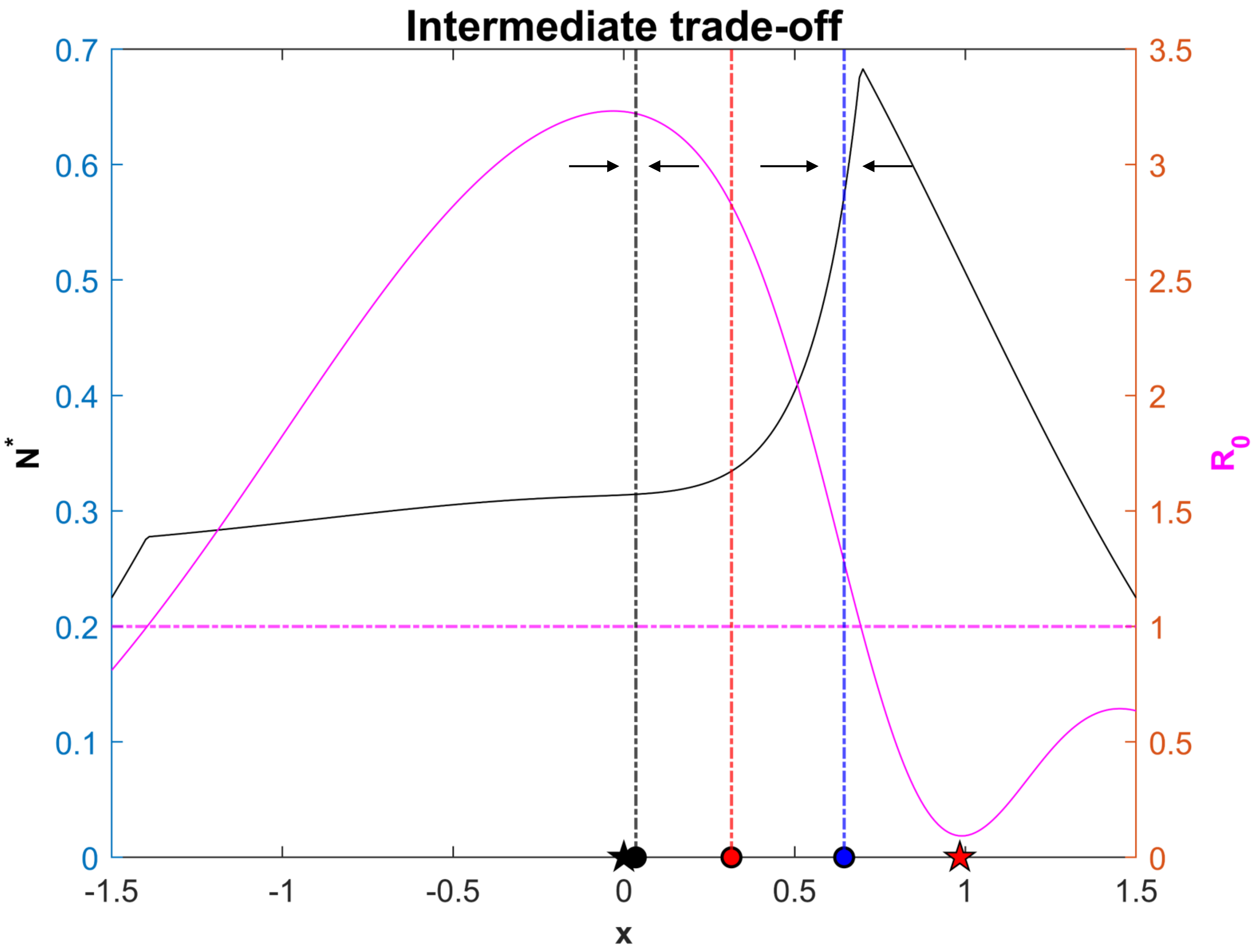
Fecundity - Transmission Trade-off



-Evolution maximizes fecundity.

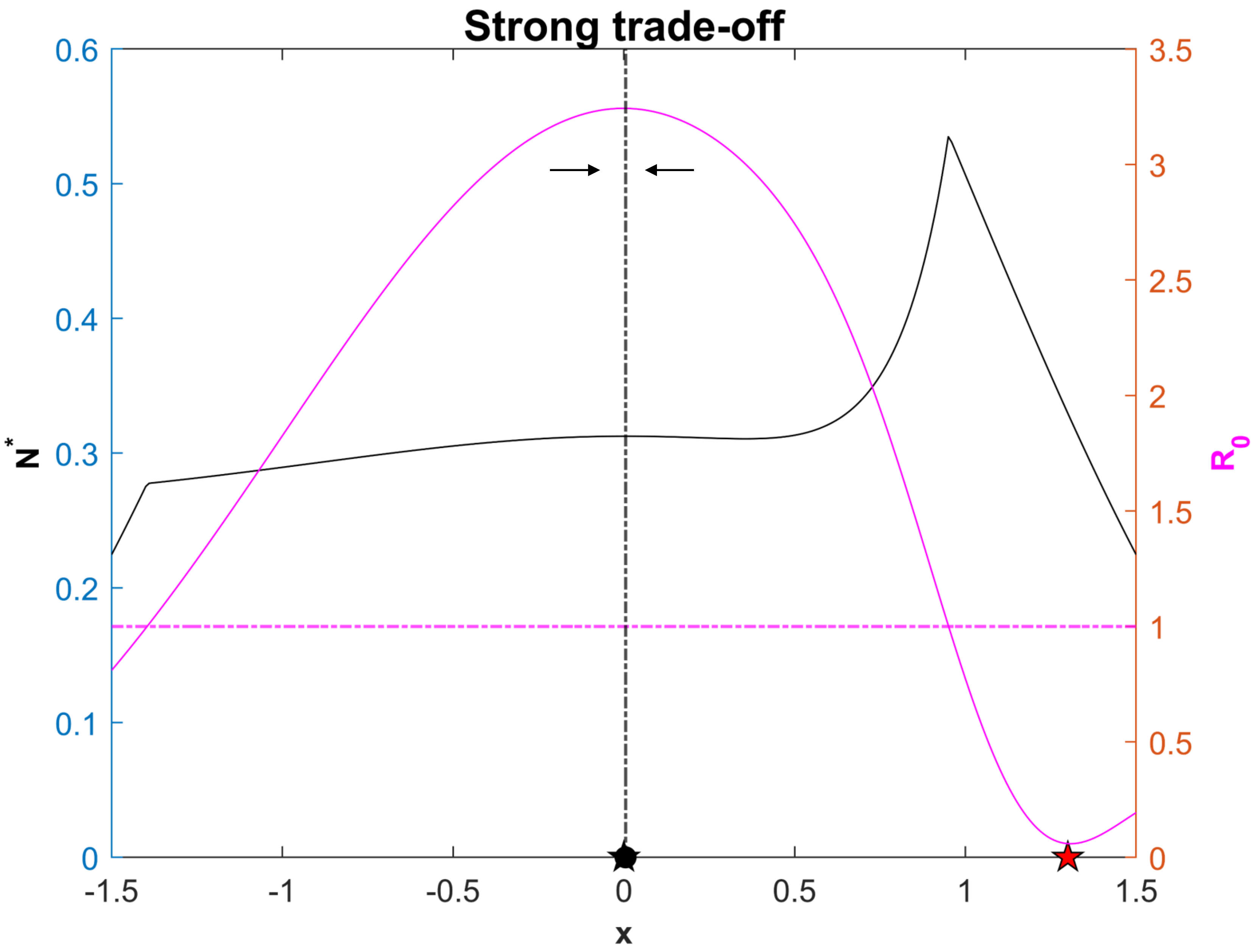
-Pathogen will go extinct.

Fecundity - Transmission Trade-off



-2 alternative strategies (1 CSS and 1 branching)

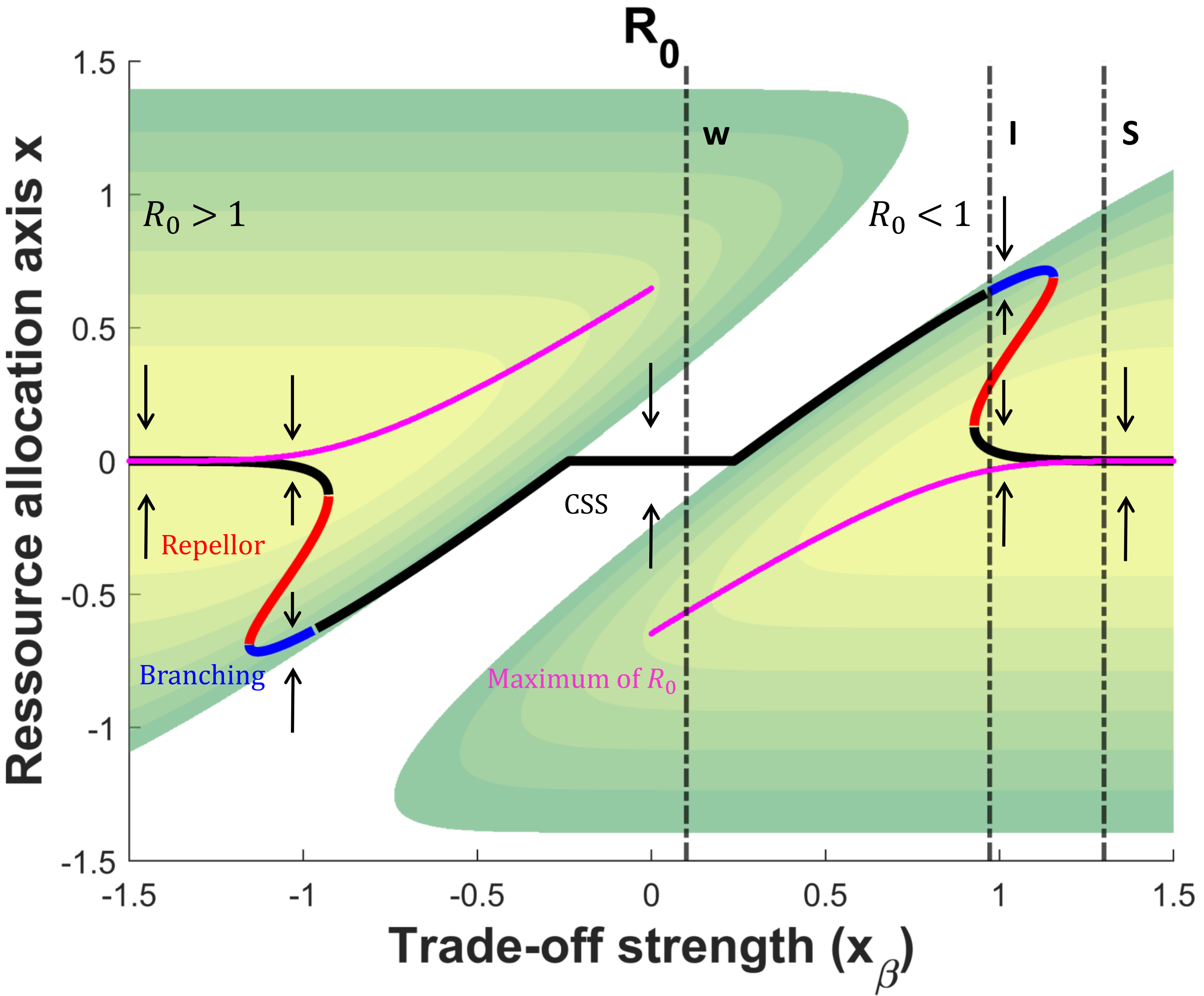
Fecundity - Transmission Trade-off



-Evolution maximizes fecundity.

-Disease propagation is the highest.

Fecundity - Transmission Trade-off (E3)



Weak trade-off

-Evolution maximizes fecundity.
-Pathogen goes extinct.

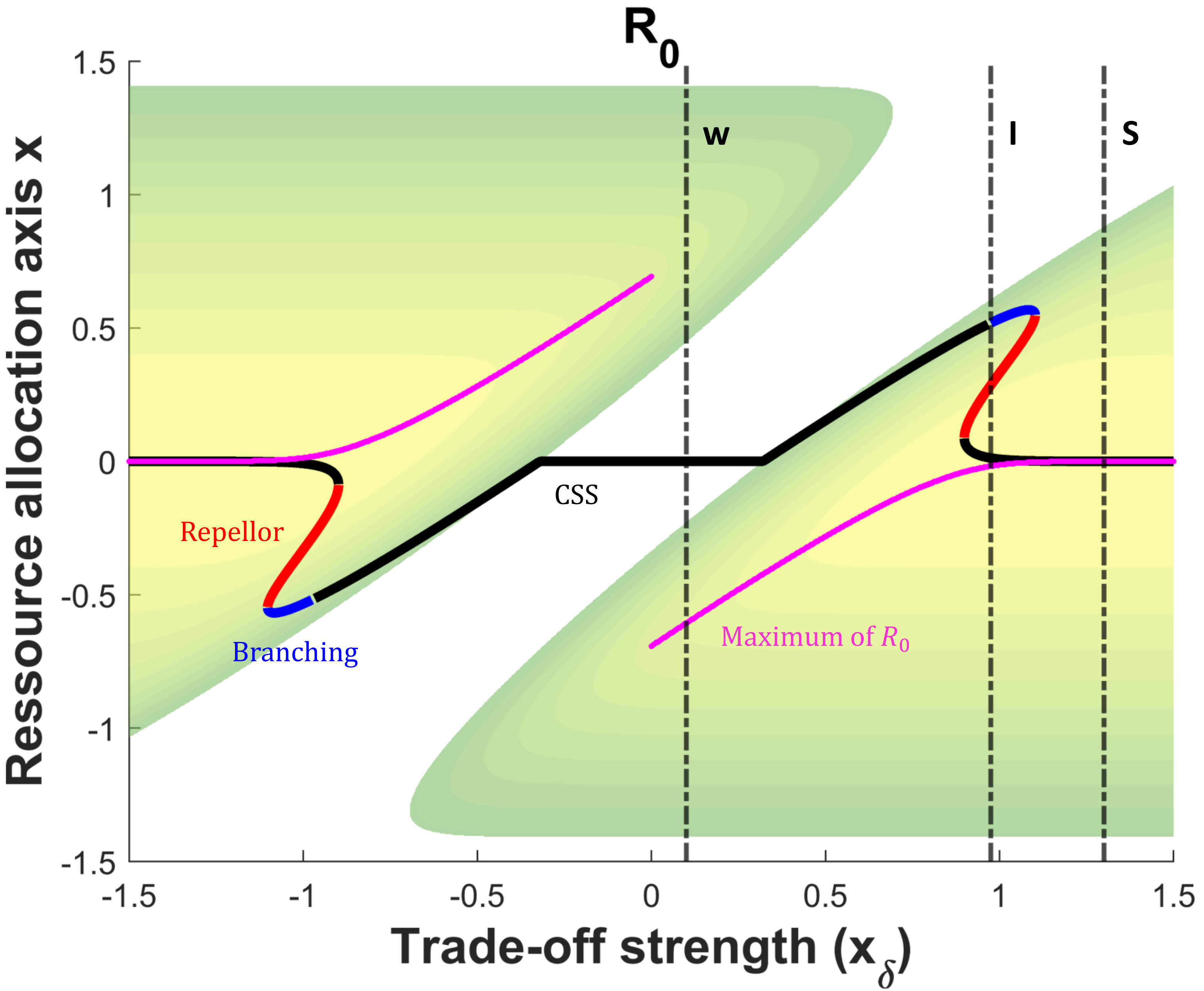
Intermediate trade-off

-2 alternative strategies

Strong trade-off

-Evolution maximizes fecundity.

Fecundity - Recovery Trade-off



Weak trade-off

-Evolution maximizes fecundity.
-Pathogen goes extinct.

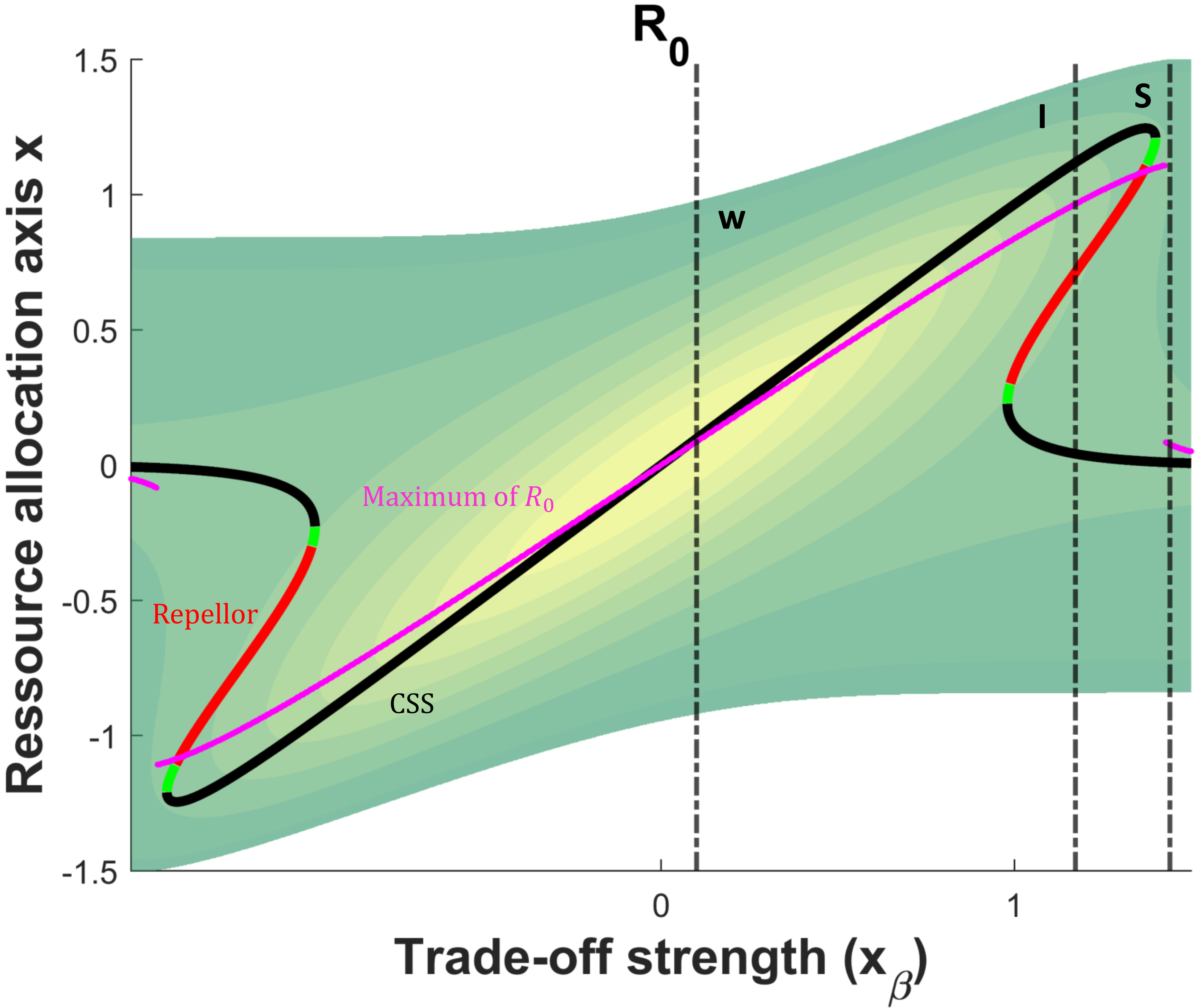
Intermediate trade-off

-2 alternative strategies

Strong trade-off

-Evolution maximizes fecundity.

Fecundity - Virulence Trade-off



Weak trade-off

-Evolution maximizes fecundity.

Intermediate trade-off

-2 alternative strategies (2 CSS)

Strong trade-off

-Evolution maximizes fecundity.

Discussion

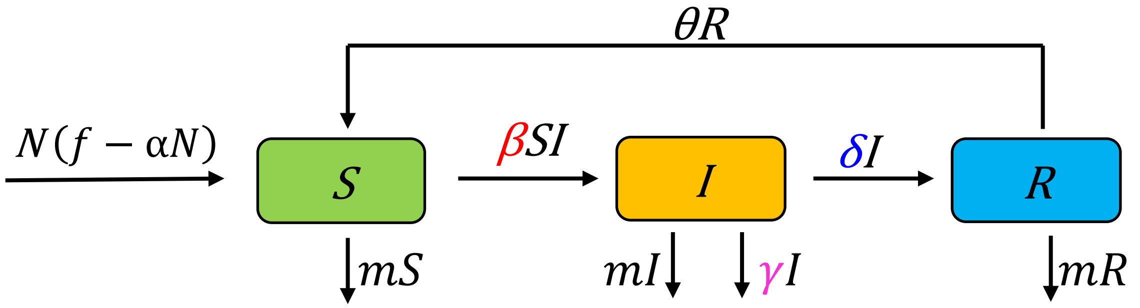
Fecundity - Transmission
Trade-off

Fecundity - Recovery
Trade-off

→ Resistance mechanisms → Same evolutionary outcomes

Fecundity - Virulence
Trade-off

→ Tolerance mechanism



Follow up questions

What are the conditions of diversification ?

Is diversity maintained in the system?

Is subsequent diversification events possible?

Thank you for your attention!

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Linh Phuong Nguyen

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