

# Empirical and theoretical opportunities in host-symbiont community ecology

Maxwell B. Joseph

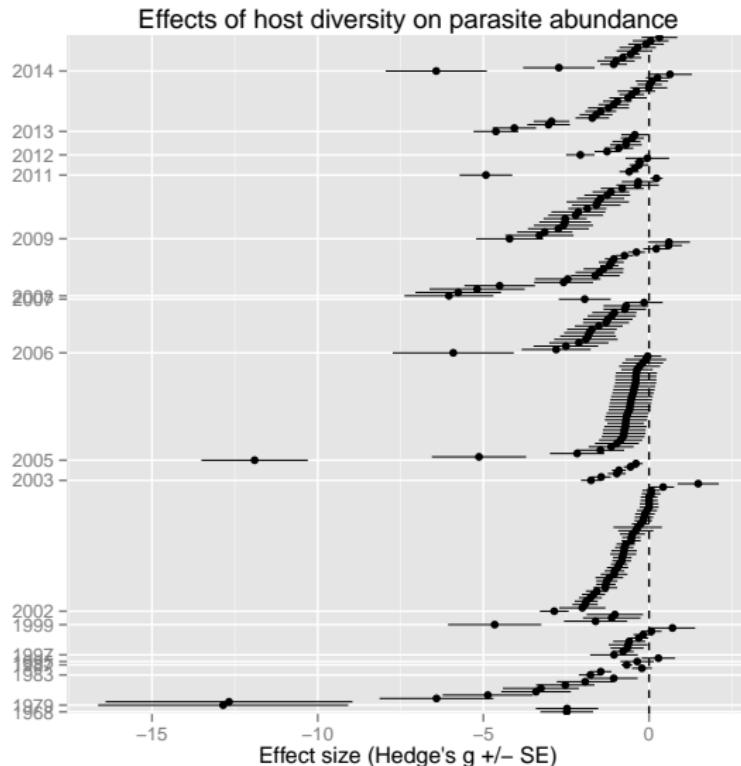
University of Colorado, Boulder, Ecology and Evolutionary Biology

[github.com/mbjoseph/esa2015](https://github.com/mbjoseph/esa2015)

## Contention

- ① 'generality'

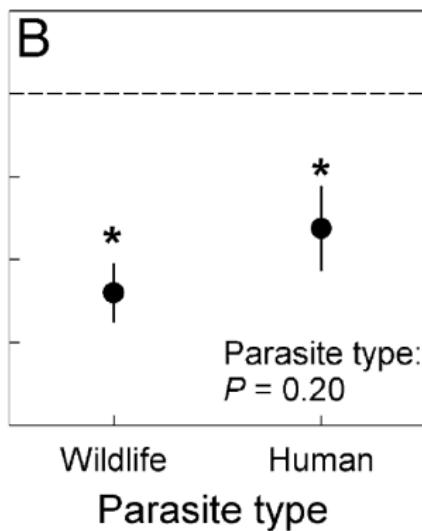
Civitello et al. 2015



## Contention

- 1 'generality'
- 2 applicability to human disease

## Applicability to human disease



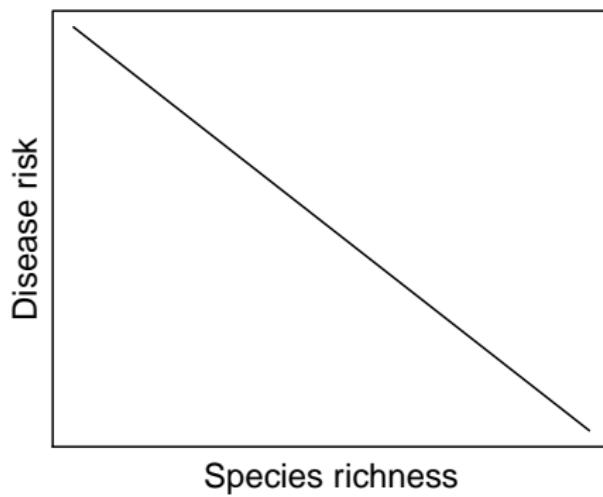
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## Contention

- 1 'generality'
- 2 applicability to human disease
- 3 justification for conservation

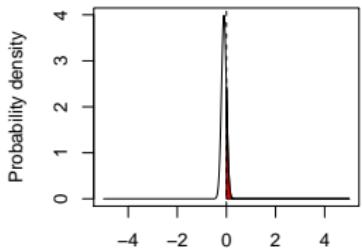
# Thought experiment

Assume that we know  $\mu_{\beta_{diversity}} < 0$



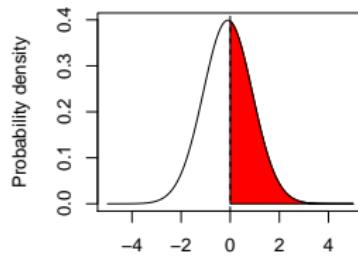
Assuming biodiversity reduces disease on average:

$$\mu_{\beta} = -0.1 \\ \sigma_{\beta} = 0.1$$



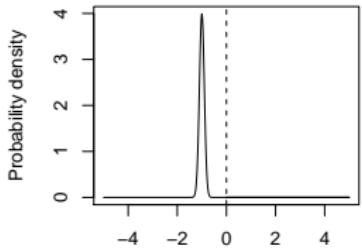
Effect of host richness on disease

$$\mu_{\beta} = -0.1 \\ \sigma_{\beta} = 1$$



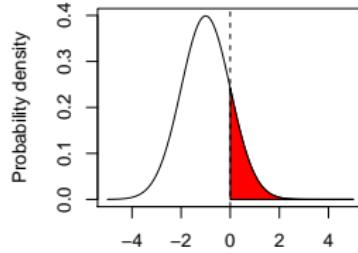
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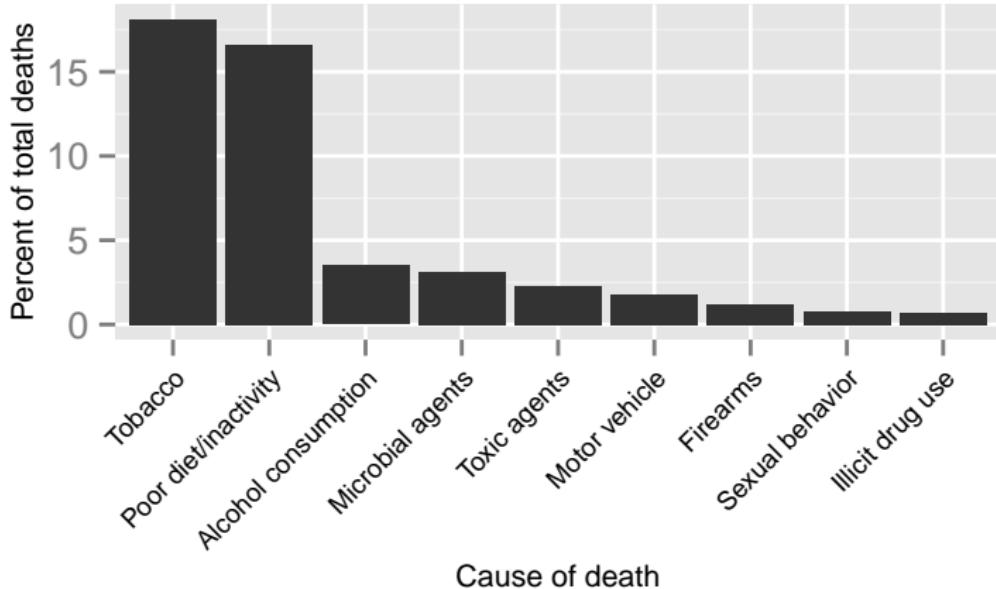
Effect of host richness on disease

**We all care about variation**

# Thought experiment

If we knew biodiversity was good for our health,  
would we conserve biodiversity?

# Actual causes of death in the U.S.



Mokdad et al. 2004.

## ① Thinking beyond the mean effect

- What explains the variance?

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## ② Transmission dynamics

Density-dependent:

$$\beta SI$$

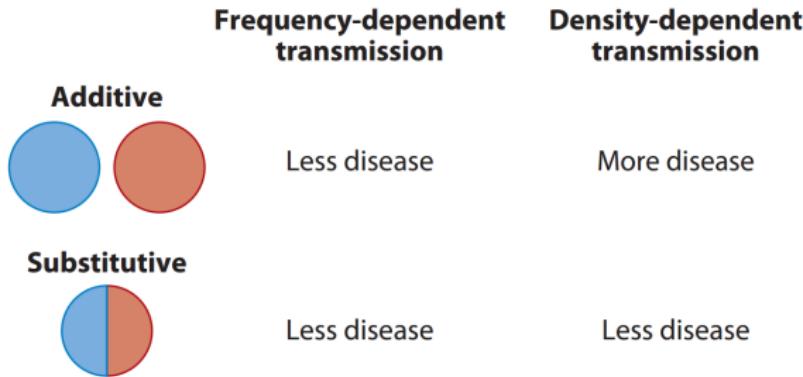


Frequency-dependent:

$$\beta SI/N$$

Contact rate independent from  $N$

# Transmission dynamics, diversity, and disease



Ostfeld and Keesing 2012

Constant risk:

$$\frac{dI}{dt} = \beta S$$

Power law:

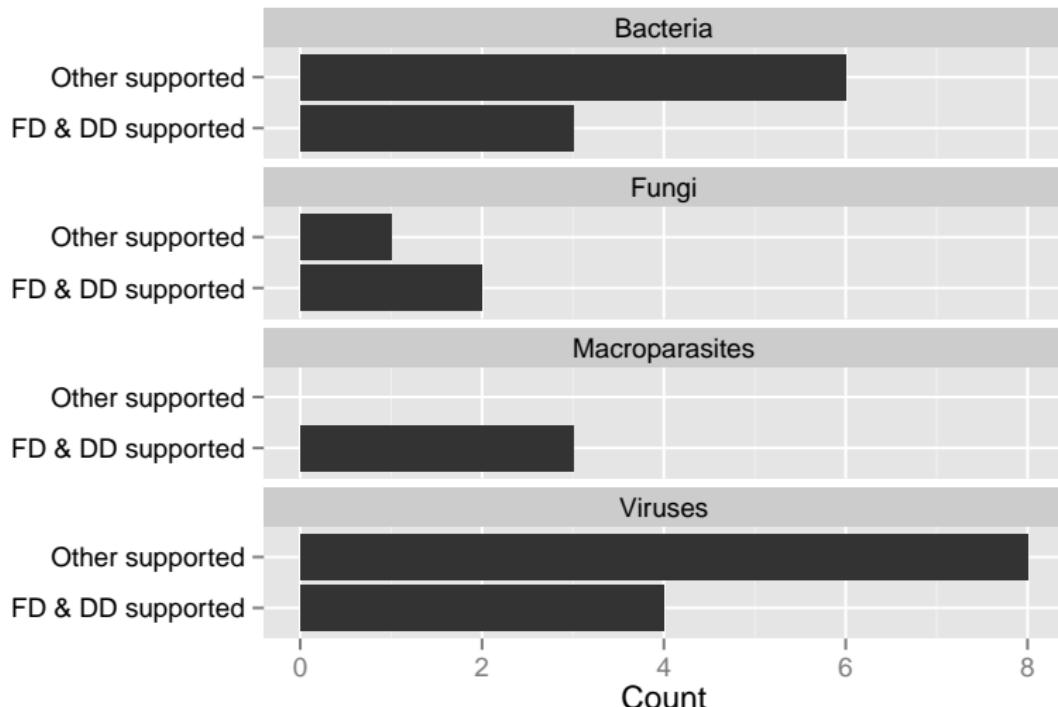
$$\frac{dI}{dt} = \beta S^p I^q$$

Negative binomial:

$$\frac{dI}{dt} = (kS) \log\left(1 + \frac{\beta I}{k}\right)$$

# Support for other transmission functions

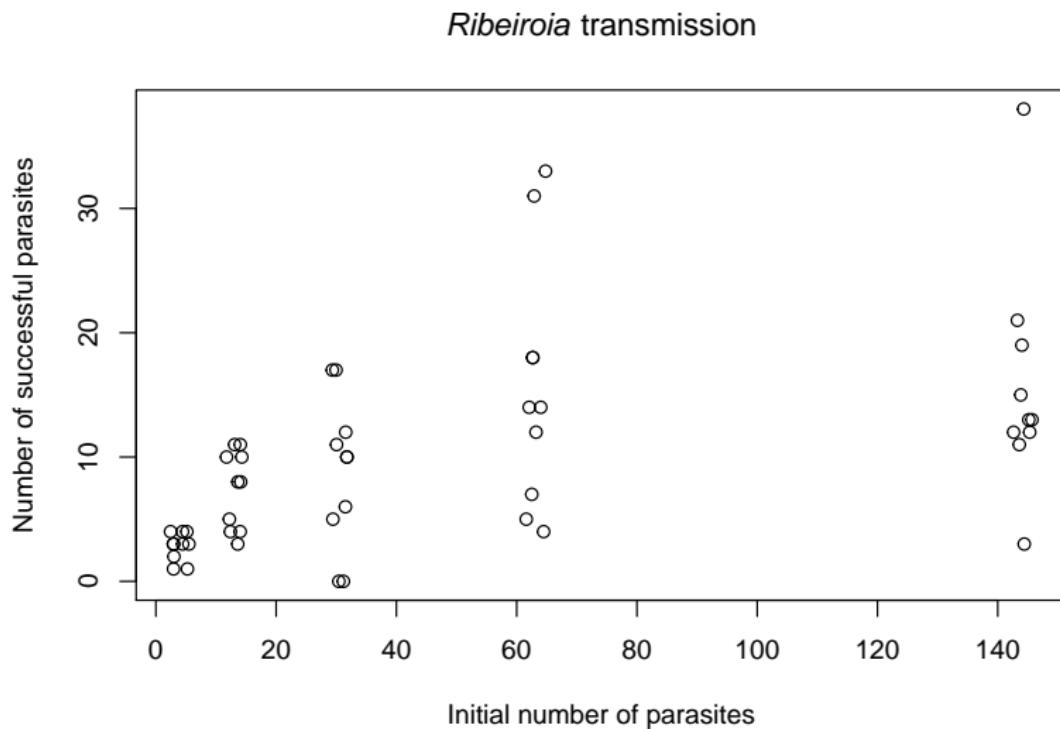
(Orlofske, Joseph, et al. *in prep*)



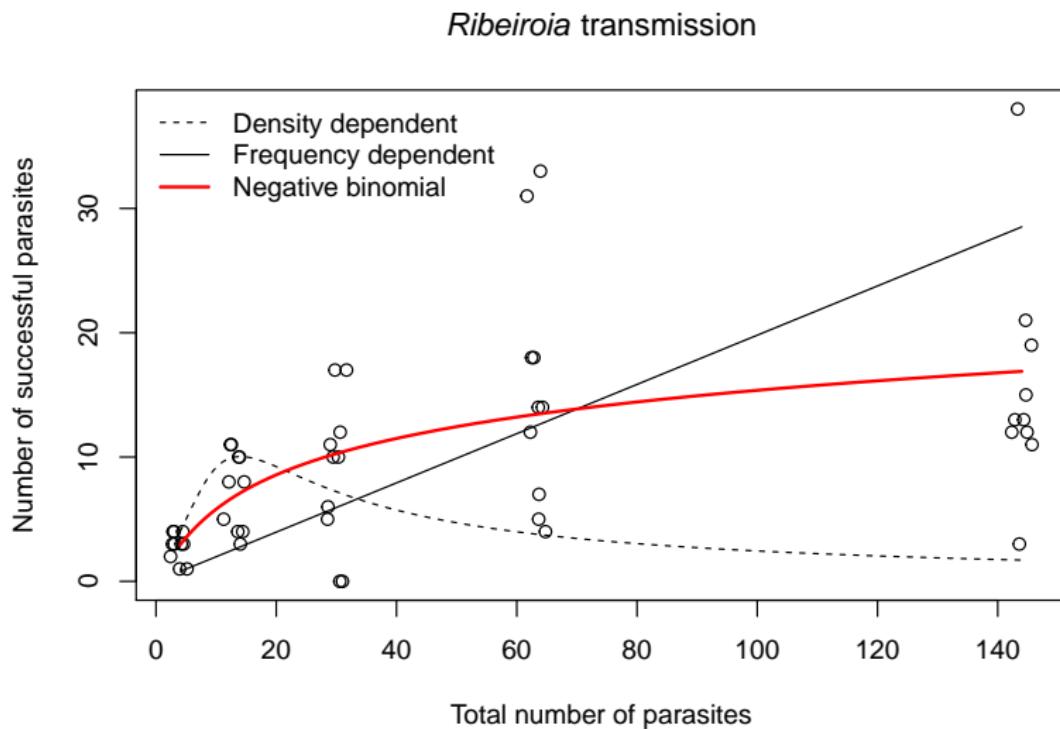
# Evaluating support for different models

- 1 Build set of transmission functions (DD, FD, etc.)
- 2 Design experiments varying:
  - $P$ : number of parasites
  - $H$ : number of hosts
  - $t$ : exposure time
  - $\frac{P}{v}$ : parasite density

# Evaluating support for different models



# Evaluating support for different models



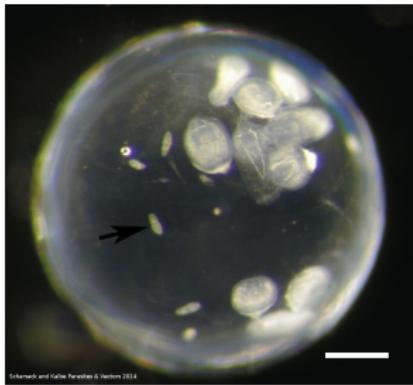
## *Ribeiroia*:

- $P$ : neg. binom.
- $H$ : power law
- $t$ : power law
- $\frac{P}{v}$ : uninformative



*Diplostomum spathaceum* (Karvonen et al. 2003):

- $\frac{P}{v}$ : neg. binom. and power law
- $P$ : power law



*Centrocestus armatus* experiments (Paller et al. 2007):

- $\frac{P}{v}$ : neg. binom.
- $P$ : neg. binom.

# Modes of transmission, diversity, and disease

- What transmission functions are supported empirically?
- What else might we expect theoretically?

## ① Thinking beyond the mean effect

- What explains the variance?

## ② Transmission dynamics

- What models have support?
- How do our predictions change?

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## ③ Biodiversity and symbionts

Questions:

① What is effect of host diversity on:

- symbiont diversity
- symbiont transmission

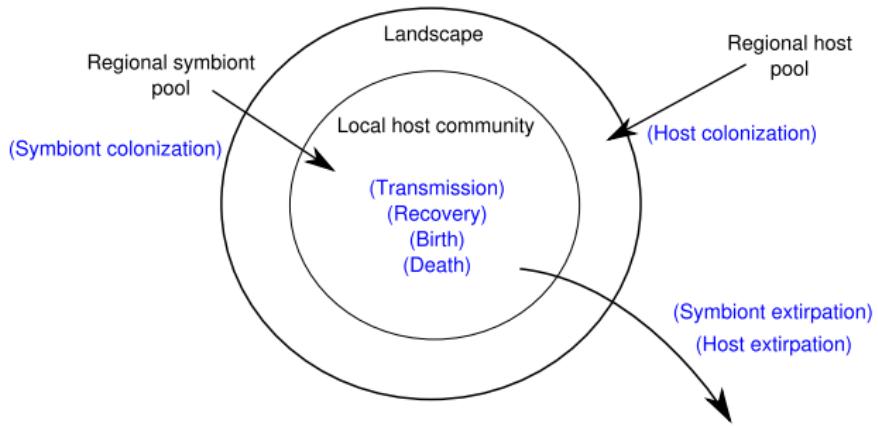
## Questions:

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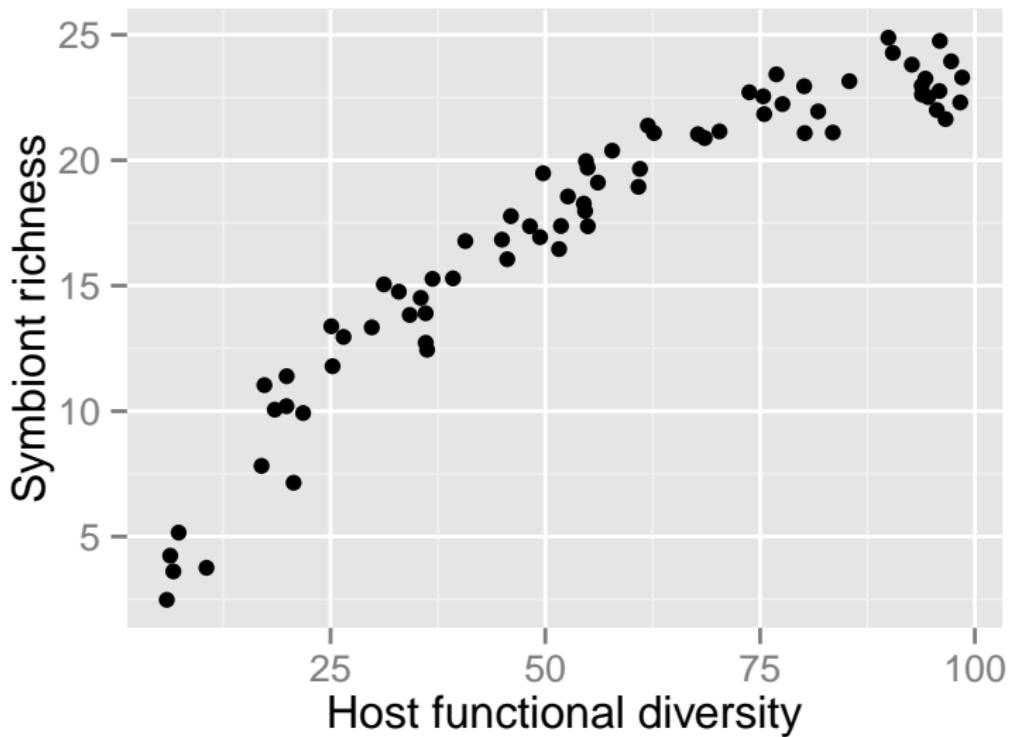
2 What role does parasitism play?

# Model structure

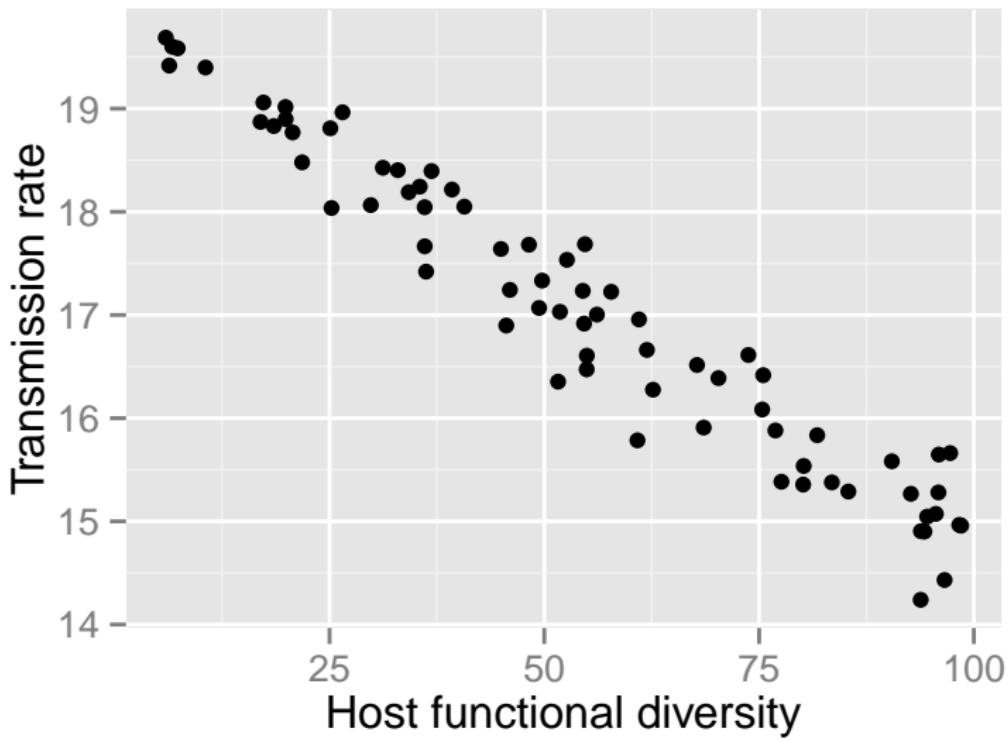


[github.com/mbjoseph/abm](https://github.com/mbjoseph/abm)

# Model predictions: diversity begets diversity



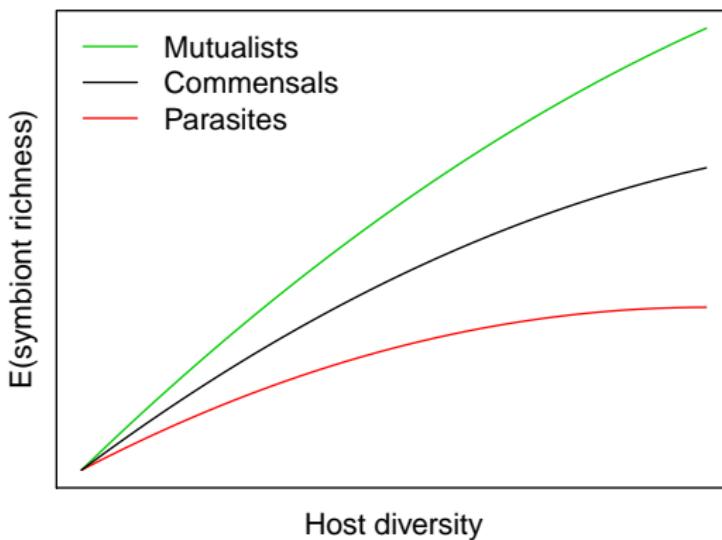
# Model predictions: diversity reduces transmission



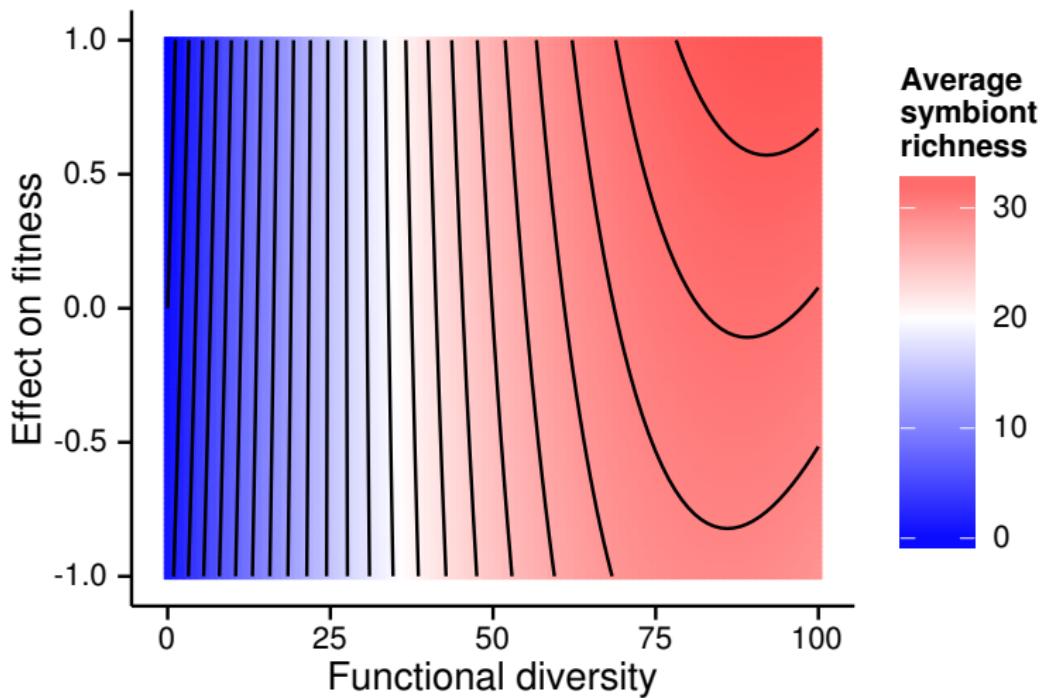
# Does disease matter?

*A priori* expectations

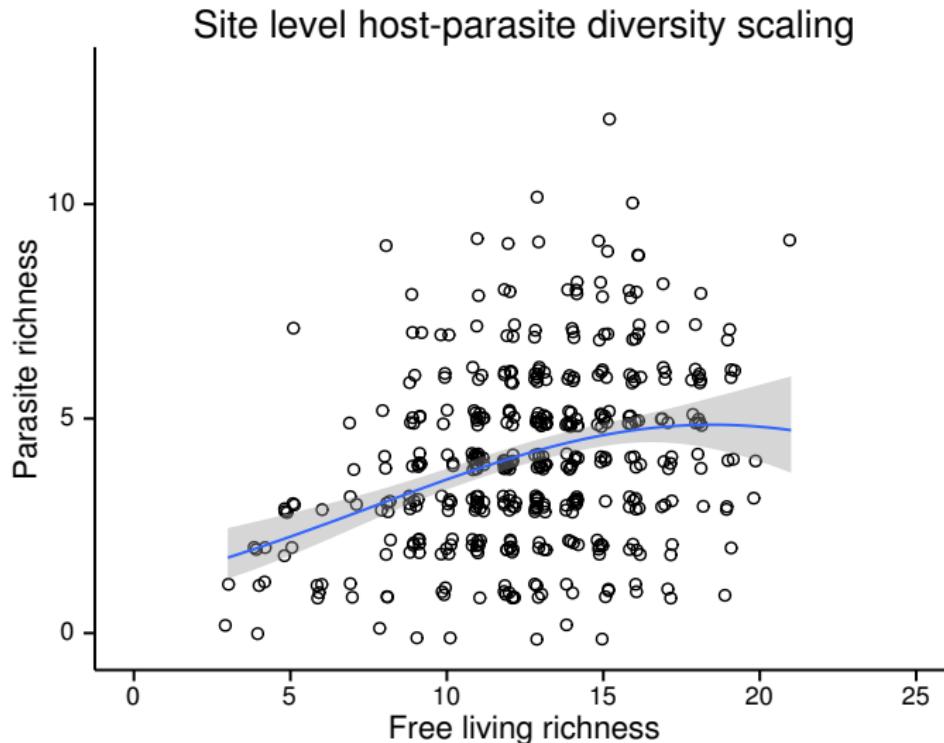
$$R_0 \propto v^{-1}$$



# Model predictions



## San Francisco Bay Area amphibian parasites



# Why symbionts in general?

- More data
- Many parasites are facultative
- Broader class of species interactions

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		+//

## ① Thinking beyond the mean effect

- What explains the variance?

## ② Transmission dynamics

- What models have support?
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## ③ Biodiversity and symbionts

- Relationships between host and symbiont diversity
- Interplay b/t host diversity and symbiont transmission
- Parasites, commensals, and symbionts

Pieter Johnson

Joseph Mihaljevic

Dan Preston

EBIO QDT

CU Research Computing

NSF GRFP

Thank you

## Local dynamics



Local dynamics → regional dynamics



# Scale transitions: theoretical results

Local dynamics  $\neq$  regional dynamics if

- local dynamics are non-linear
- densities vary spatially
- conditions vary spatially

(Chesson et al. 2005)

Lots of theory (but see Roche et al. 2012): instantaneous rates

- transmission
- $R_0$
- force of infection

Most data: integrated quantities

- prevalence
- seroprevalence
- density of infected hosts

# Biodiversity and symbionts

Similar to habitat area-heterogeneity trade-off in free living species

