Parasites: Can Little Things Eat Big Things?

Nick

August 5, 2016

1. Motivation
2. Food Web Models
3. Identifying Parasites
4. Numerical Experiments

Parasitism in Food Webs

- Underrepresentation

Parasitism in Food Webs

- Underrepresentation
- Novel, complex, and specific

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- Underrepresentation
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- Place in Food Webs

Past Work

- Effect of Adding Parasites [1]

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- Importance of Body Size Ratios [2]
- An Inverse Niche Model [3]

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Research Goals

- Niche Model vs. Inverse Niche Model(s)

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- Dynamical Simulations

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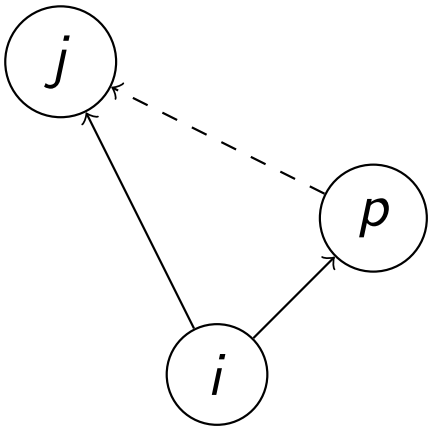
- Dynamical Simulations
- Concommitant (Incidental) Predation



Empirical Data

- Bahia San Quintin, Estero de Punta Banda (bahia,punta)
  - Pics
  - View
  - Bird
- Carpinteria Salt Marsh (carp)
- Otago Harbor (otago)
- Sylt Tidal Basin (sylt)
- Flensburg Fjord (flens)

Empirical Data

- Bahia San Quintin, Estero de Punta Banda (bahia,punta)
- Carpinteria Salt Marsh (carp)
  - Aerial
  - Close
  - Flowers
- Otago Harbor (otago)
- Sylt Tidal Basin (sylt)
- Flensburg Fjord (flens)

Empirical Data

- Bahia San Quintin, Estero de Punta Banda (bahia,punta)
- Carpinteria Salt Marsh (carp)
- Otago Harbor (otago)
  - Map1
  - Map2
  - Far
- Sylt Tidal Basin (sylt)
- Flensburg Fjord (flens)

Empirical Data

- Bahia San Quintin, Estero de Punta Banda (bahia,punta)
- Carpinteria Salt Marsh (carp)
- Otago Harbor (otago)
- Sylt Tidal Basin (sylt)
  - Map1
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  - Road
- Flensburg Fjord (flens)

Empirical Data

- Bahia San Quintin, Estero de Punta Banda (bahia,punta)
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- Otago Harbor (otago)
- Sylt Tidal Basin (sylt)
- Flensburg Fjord (flens)
  - Map1
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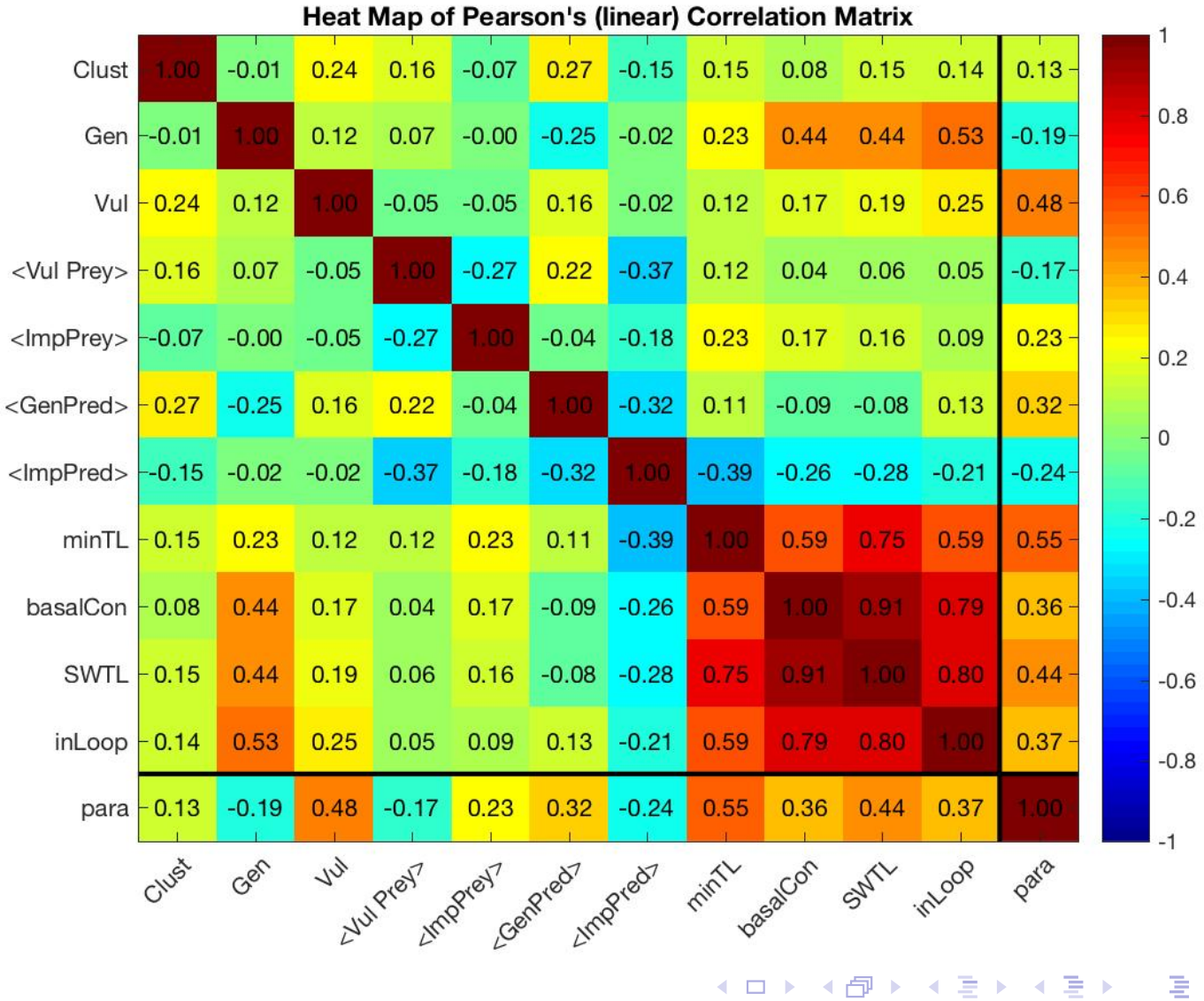
Empirical Data

Parasitic Webs	S	C	S_{free}	S_{free}	S_{basal}
bahia	141	.092	.35	.65	.06
carp	154	.085	.36	.64	.06
punta	185	.084	.37	.63	.05
flens	109	.073	.38	.62	.06
otago	117	.077	.15	.85	.03
sylt	147	.079	.20	.80	.04

Free Webs	S	C	S_{par}	S_{free}	S_{basal}
bahia	80	.085	0	1	.11
carp	91	.096	0	1	.10
punta	106	.099	0	1	.08
flens	56	.11	0	1	.11
otago	94	.085	0	1	.04
sylt	117	.073	0	1	.05

Empirical Data

Number	Name
1	clustCoef
2	gen
3	vul
4	<vulPrey>
5	<impPrey>
6	<genPred>
7	<ImpPred>
8	minTL
9	basalCon
10	SWTL
11	inLoop
12	para



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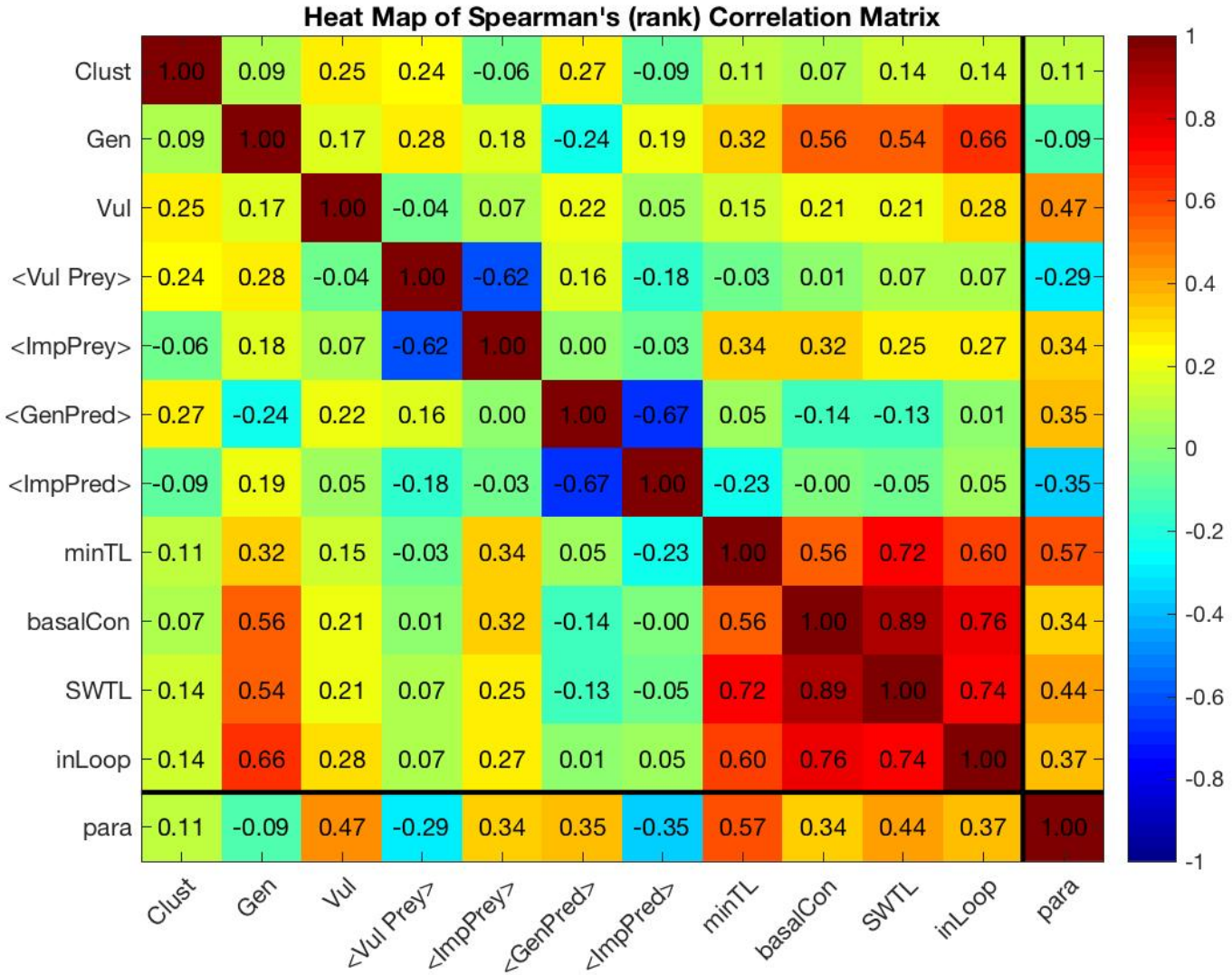
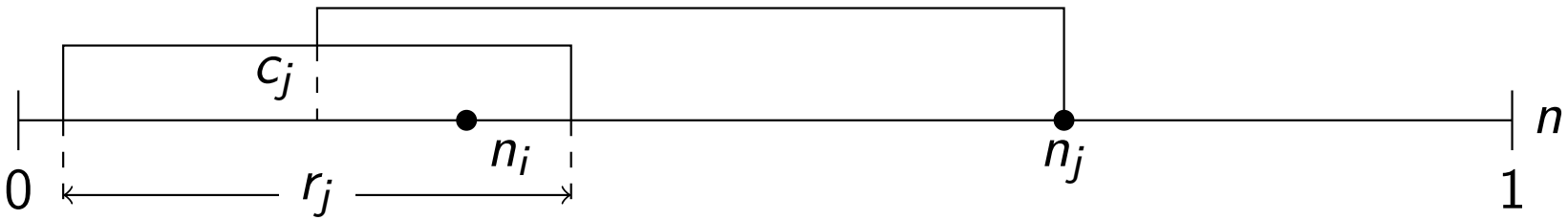
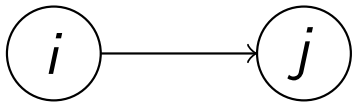


Inverse Niche Models





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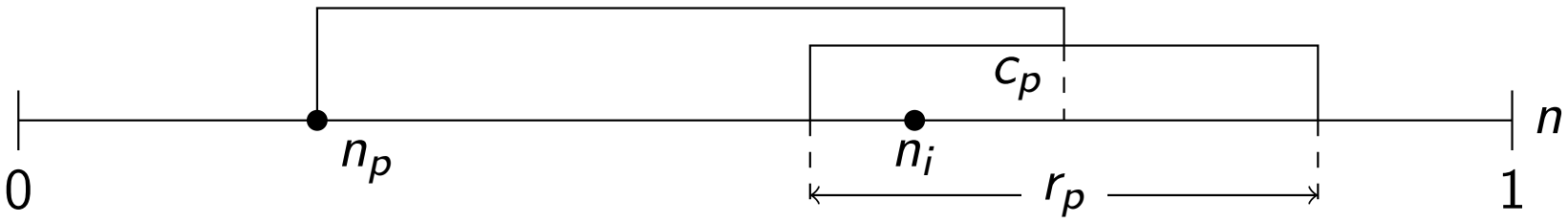

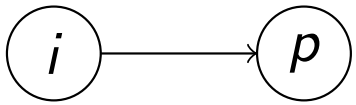

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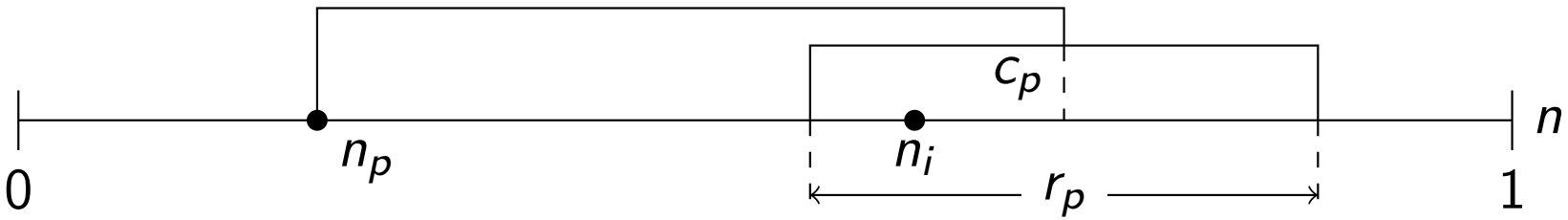
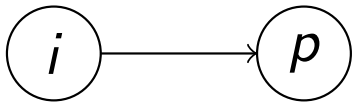
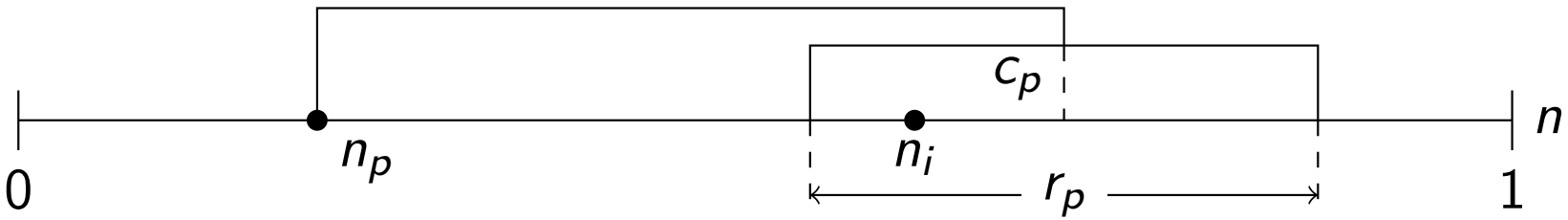
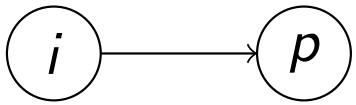




- $n_p \sim U(a, b)$

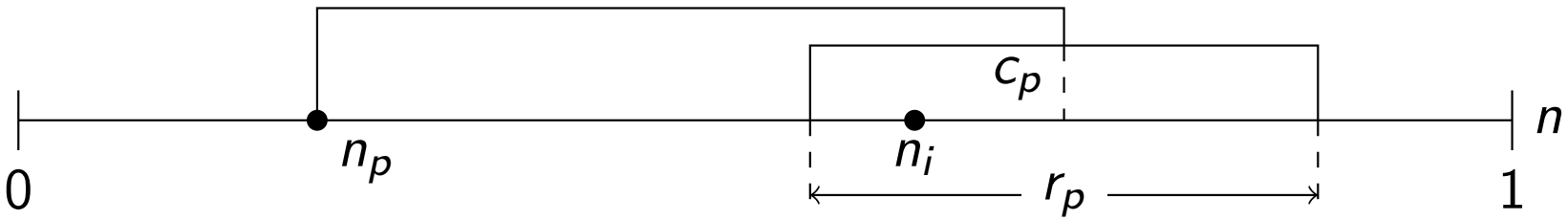
Inverse Niche Models

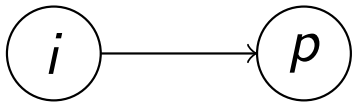




- $n_p \sim U(a, b)$
- $y_p \sim \text{Beta}(1, \beta_p)$

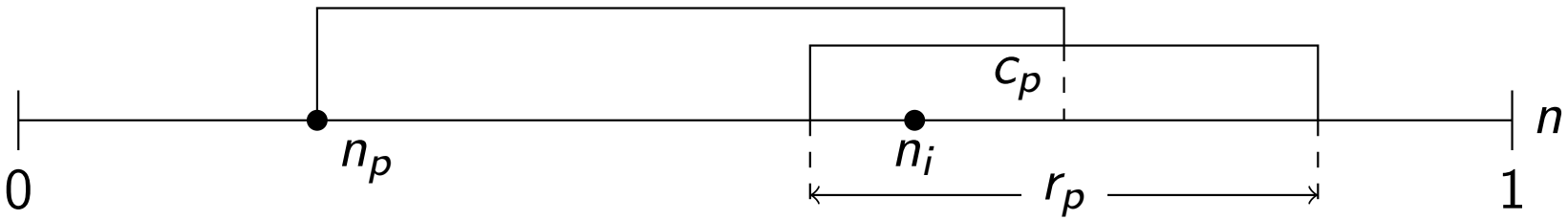
Inverse Niche Models

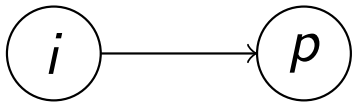




- $n_p \sim U(a, b)$
- $y_p \sim \text{Beta}(1, \beta_p)$
- $r_p \sim (1 - n_p) \cdot y_p$

Inverse Niche Models





- $n_p \sim U(a, b)$
- $y_p \sim \text{Beta}(1, \beta_p)$
- $r_p \sim (1 - n_p) \cdot y_p$
- $c_p \sim U(\max(n_p, r_p/2), 1 - r_p/2)$

Inverse Niche Models: Further Issues

- Types of links; sub-web connectances

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- Types of links; sub-web connectances
- Diet intersections with parasitic niches
- Scale dependent errors vs. Parasitic errors
- Low(?) parasitic resolution

Proposed Models

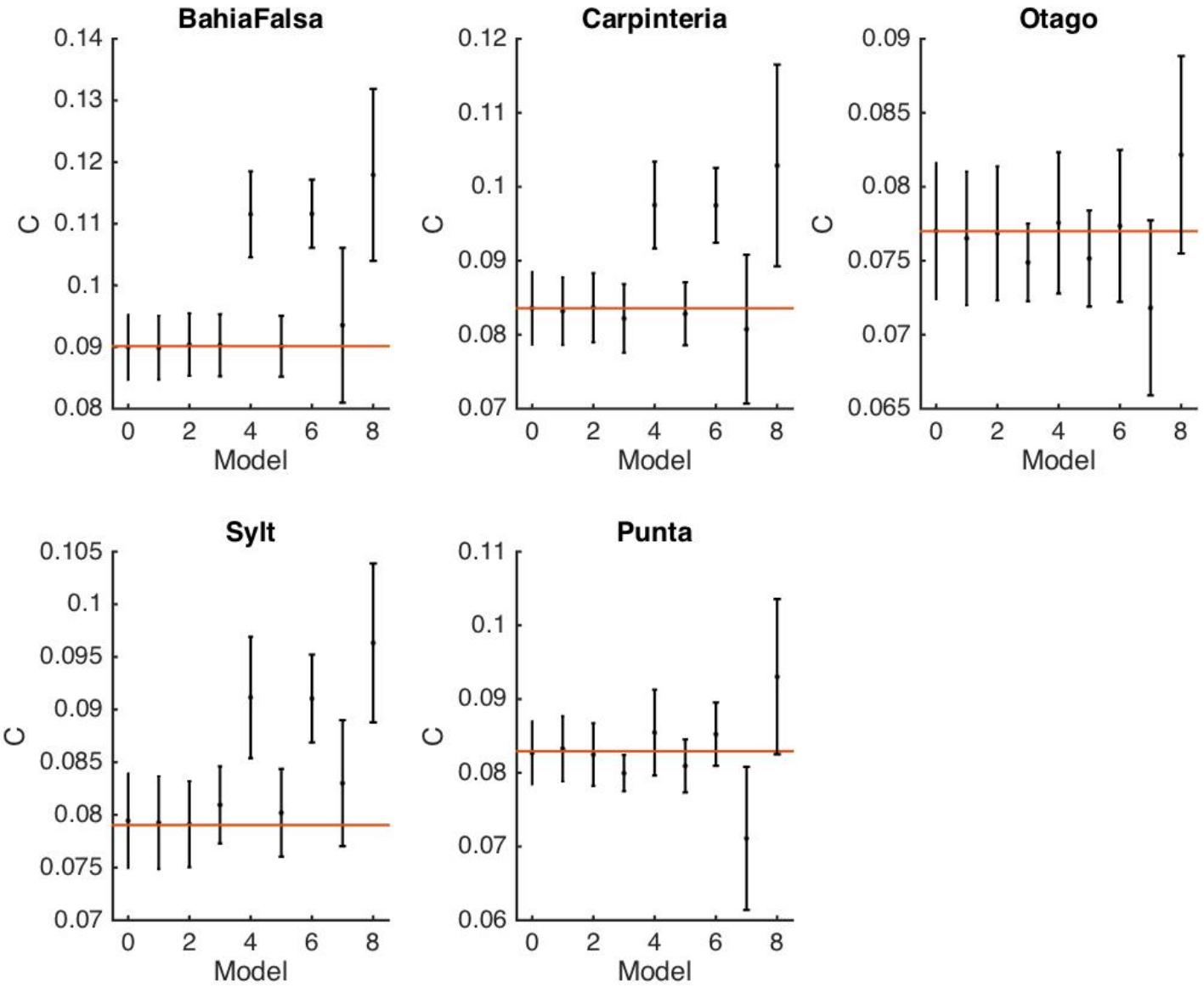
All at once models:

	Description
Model 0	Plain Niche Model
Model 1	Random parasites; correct bias; eat below
Model 2	Random parasites; correct bias; eat above

Adding to niche web models:

	$\min(n_p)$	$\max(n_p)$	Invert Parasites	Match C_{fp}
Model 3	0	1	no	no
Model 4	0	1	no	yes
Model 5	0	1	yes	no
Model 6	0	1	yes	yes
Model 7	0.7	0.9	no	yes
Model 8	0.1	0.3	yes	yes
Model 9	0.1	0.3	yes	no
Model 10	0.7	0.9	no	no

(Selected) Results of models



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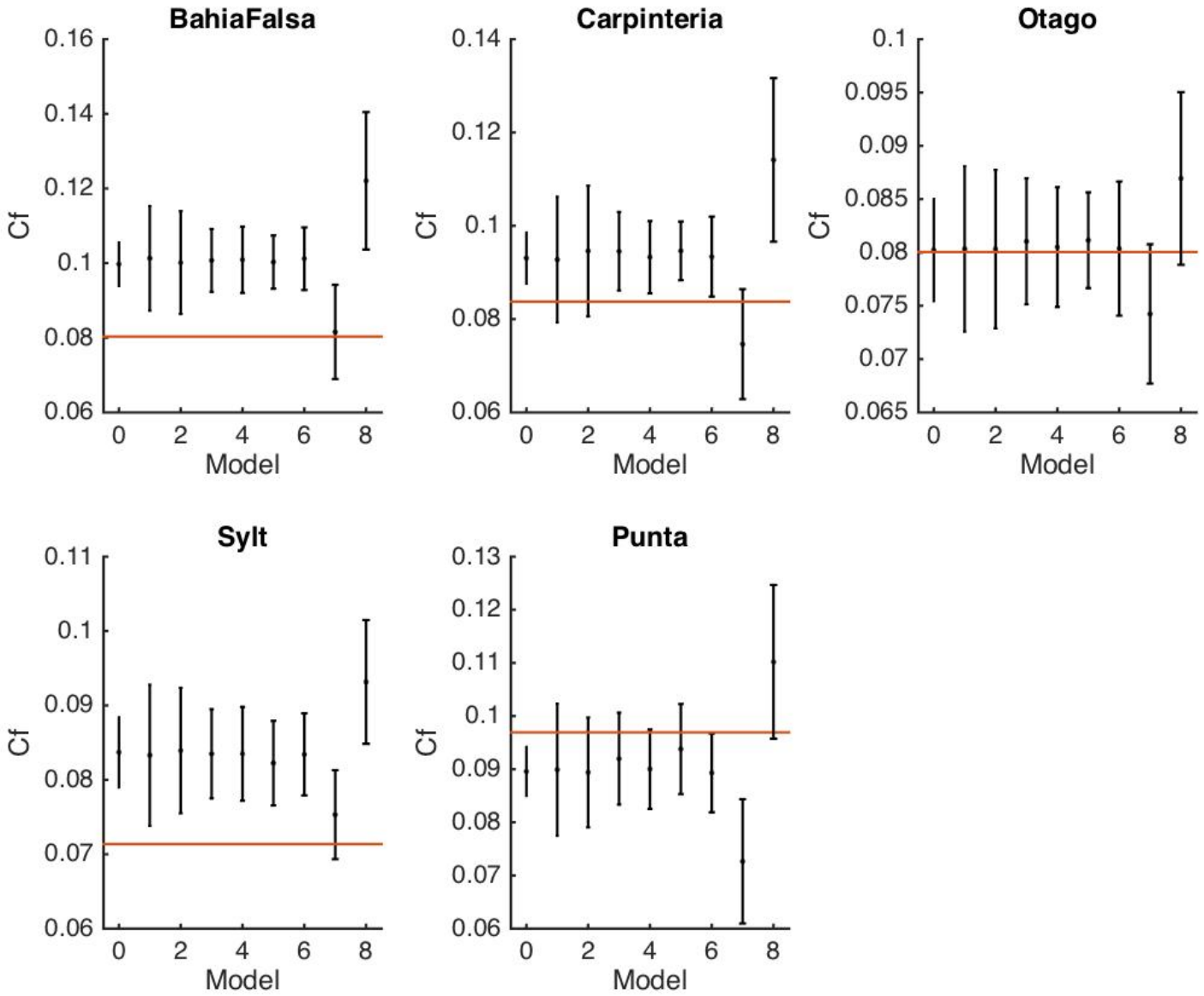

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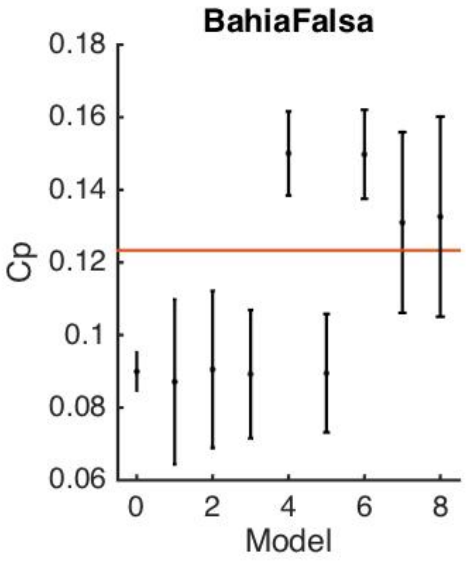

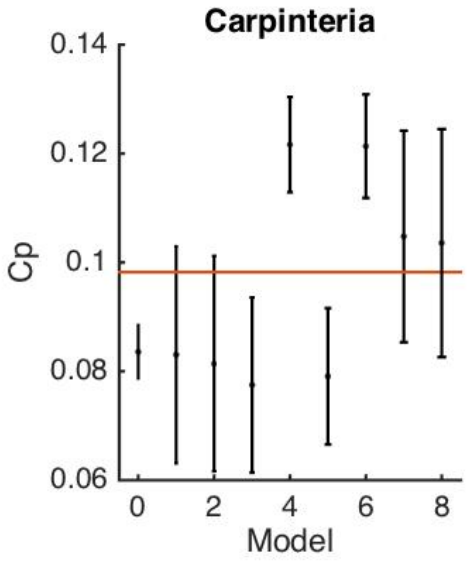

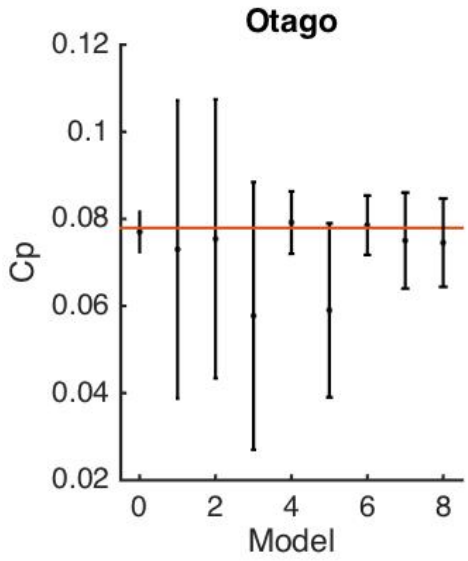

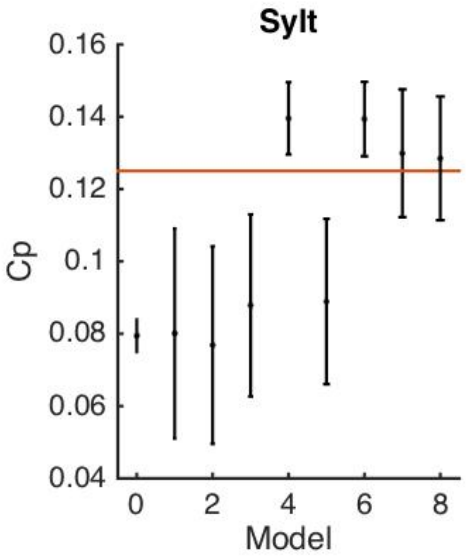

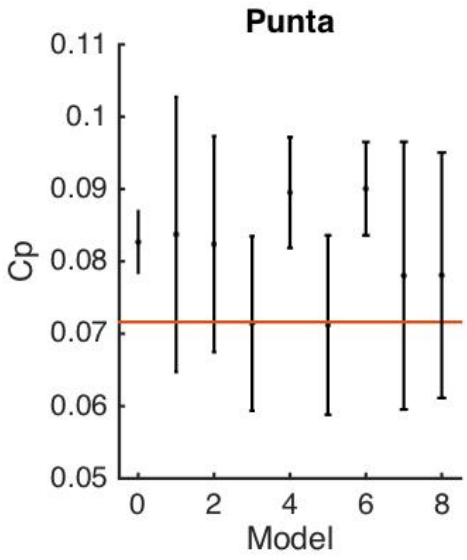

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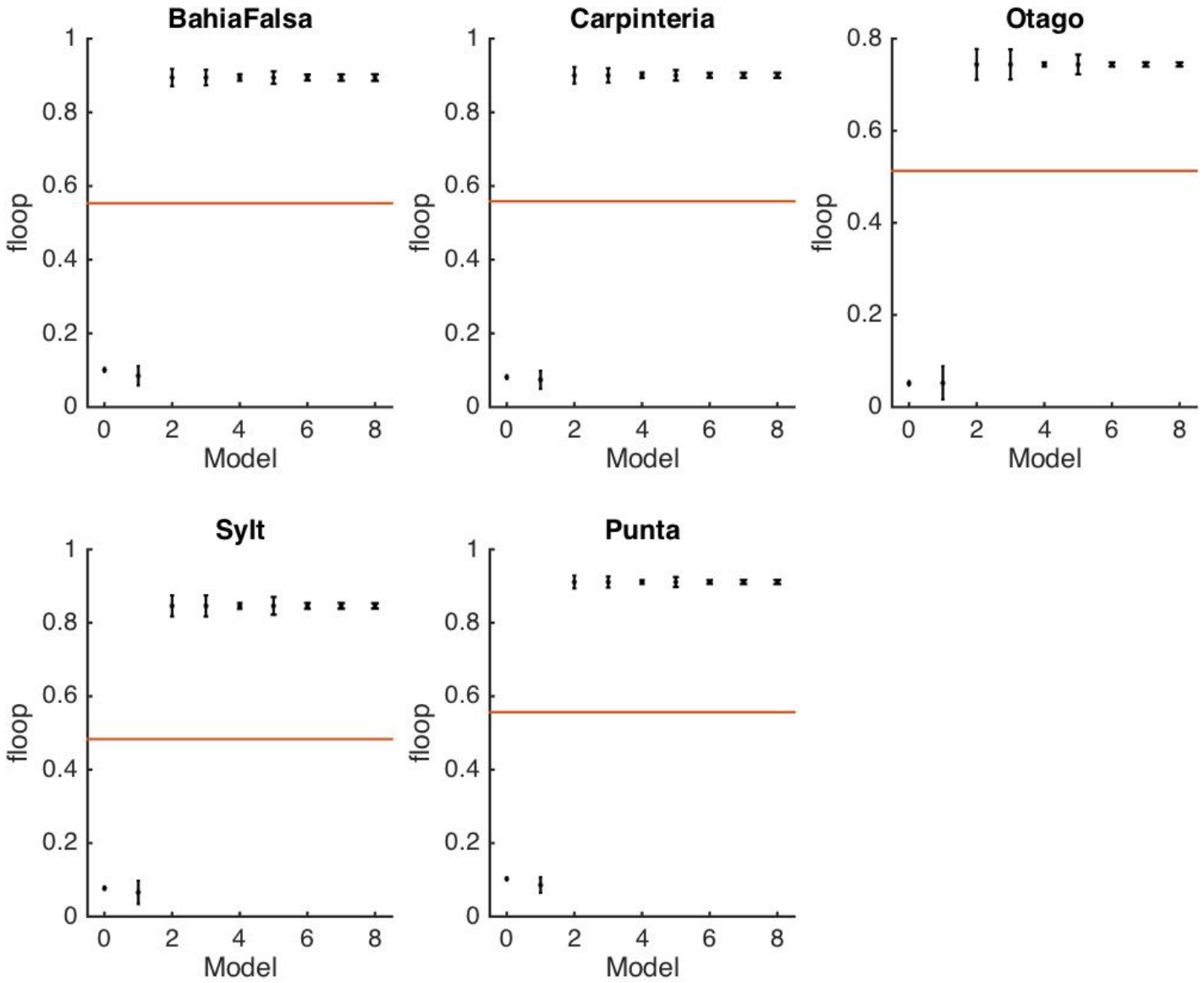

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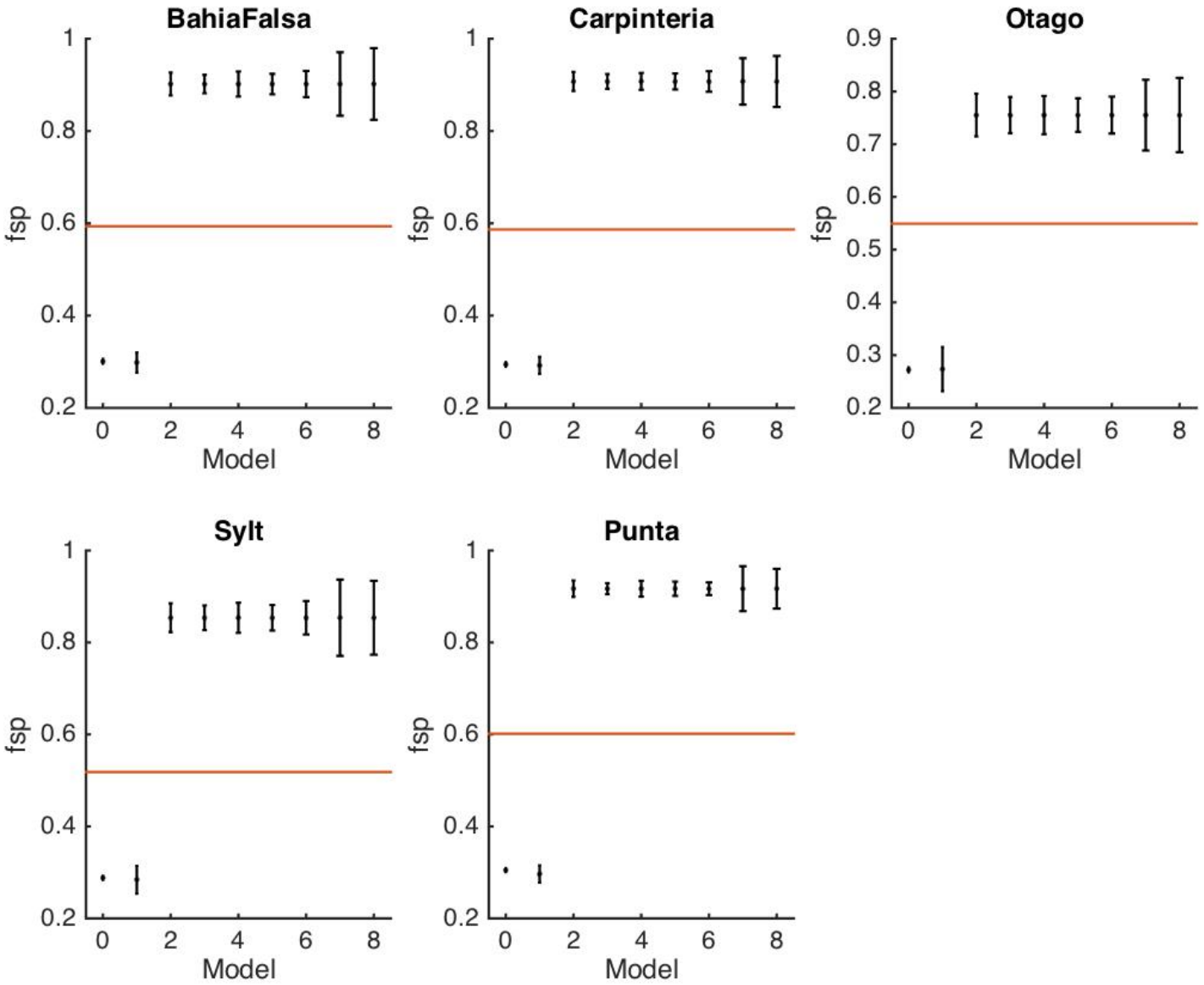

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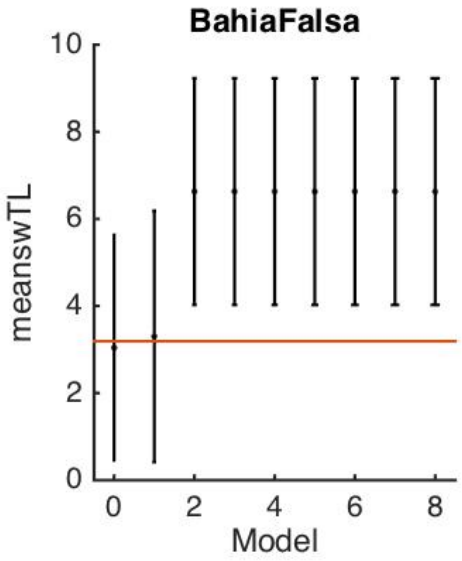

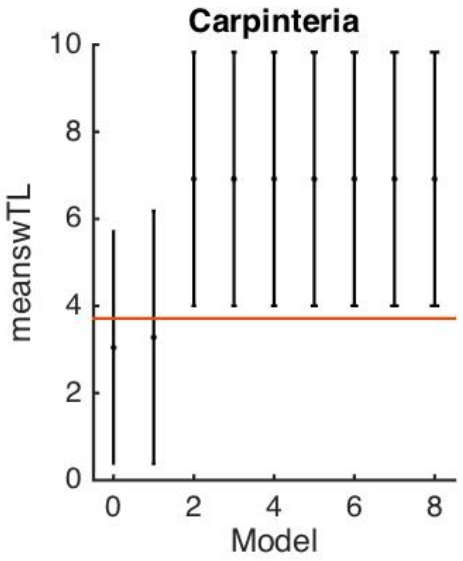

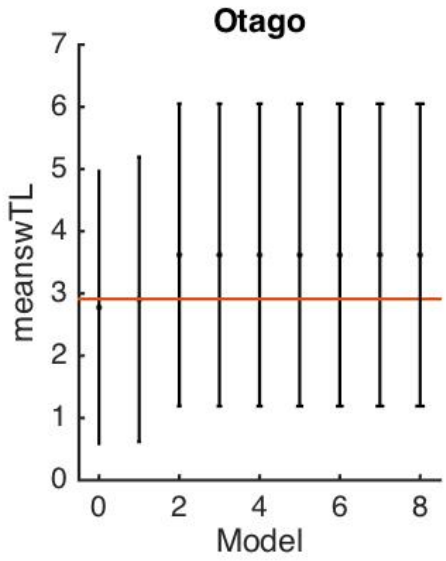

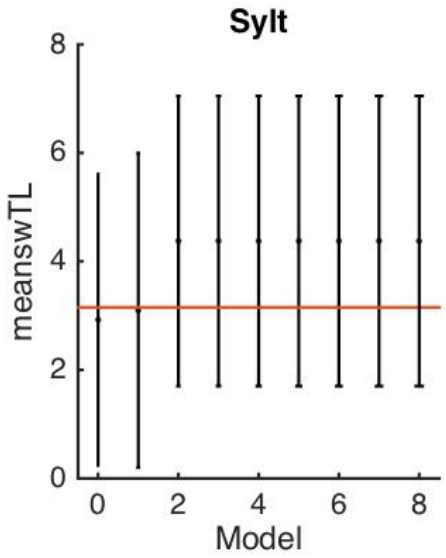

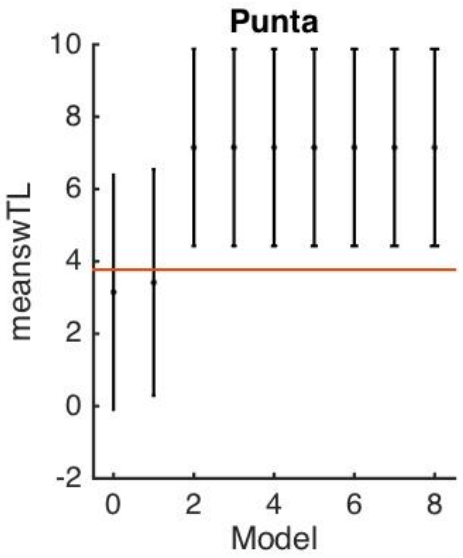

Empirical Data Revisited

Generalities of Free-Living Consumers and Parasites

Web	$G_f, (n_f)$	$G_p, (n_p)$	P-value
bahia	0.8984,(83)	1.355,(49)	.0091
carp	1.012,(88)	1.161,(56)	.3835
punta	1.173,(108)	0.8570,(68)	.0310
flens	1.190,(62)	0.8595,(41)	.0714
otago	1.040,(96)	1.012,(17)	.8857
sylt	.9019,(112)	1.586,(29)	.0036

Empirical Data Revisited

- Independence

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- Empirical

Empirical Data Revisited

- Independence
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- Matching Dunne et al 2013.

Empirical Data Revisited; Local

P-values for testing $\mu_{free} - \mu_{para} \neq 0$ for each property:

web	clustCoef	gen	vul	meanVulPrey	meanImpPrey
bahia	-0.11	0.0081	-1.6e-10	0.46	-0.85
carp	-0.47	1.4e-05	-2.2e-08	0.0063	-0.1
punta	-0.59	1.5e-10	-7.2e-14	0.00047	-0.015
flens	-3.1e-09	0.00016	-0.2	1.7e-05	-0.086
otago	-0.56	0.078	-0.00016	5e-14	-0.0028
sylt	0.065	0.72	-6.2e-12	2e-10	-0.013

web	meanGenPred	meanImpPred	minSPToBasal	numConnBasal	SWTL	inLoop
bahia	-2.2e-08	4.3e-07	-5.9e-16	-2e-07	-1.9e-09	-5.6e-08
carp	-3.8e-06	6.5e-07	-4.3e-15	-0.0042	-2e-05	-0.0024
punta	-1e-13	3.4e-11	-7.1e-23	-3.3e-07	-2.3e-10	-2.3e-07
flens	-8.2e-10	2.3e-07	-5.1e-15	-2.1e-07	-9.2e-15	-2.1e-10
otago	-0.45	0.4	-1.1e-12	-0.13	-1.5e-06	-0.018
sylt	-6e-05	0.029	-5.9e-19	-5.7e-07	-1.2e-15	-6.5e-10

A Classification Tree

- Binary Splits

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- 4 classes

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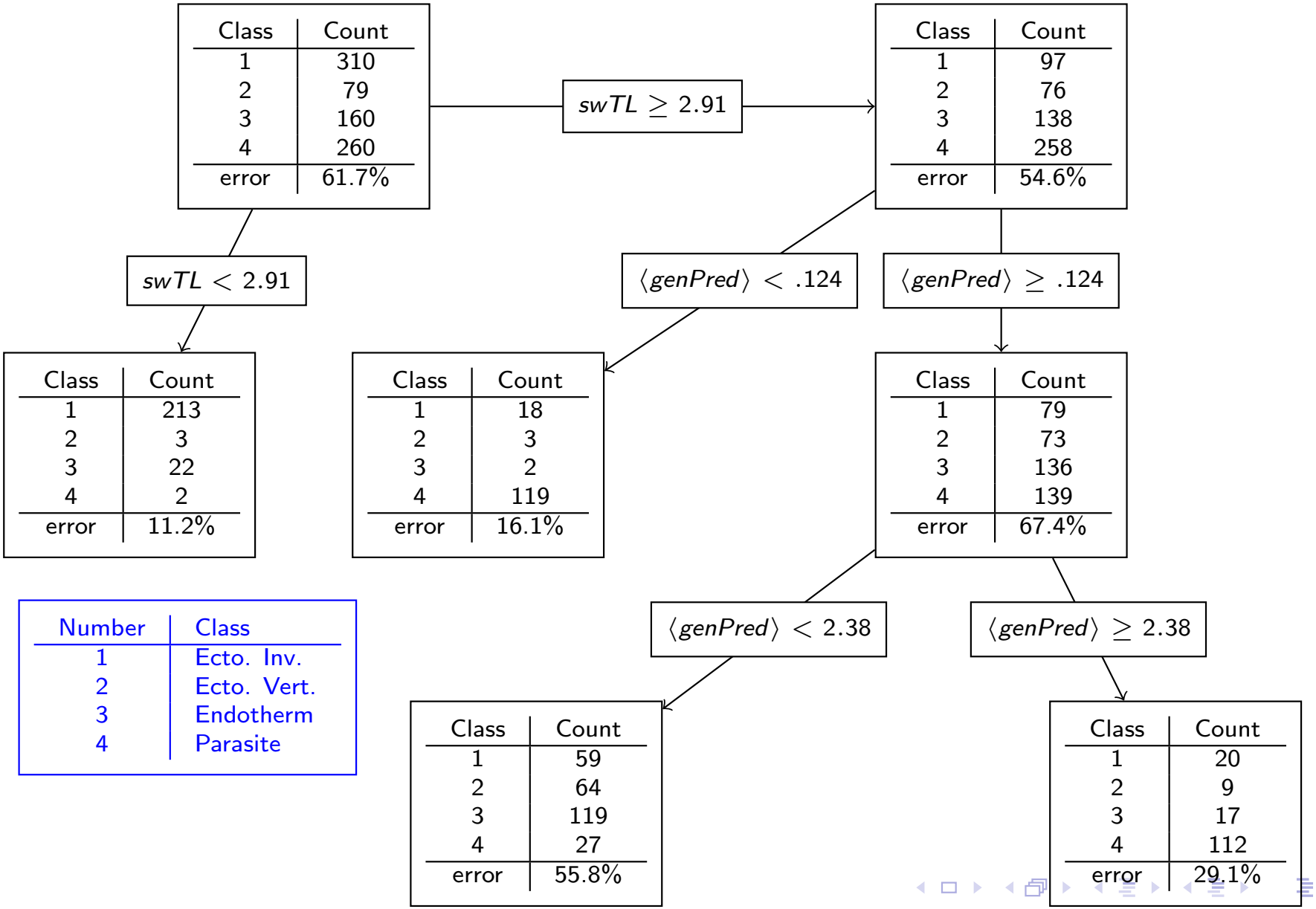
- Species Overlap?

A Classification Tree

- Binary Splits
- 4 classes
- Species Overlap?
- How to use?

A Classification Tree



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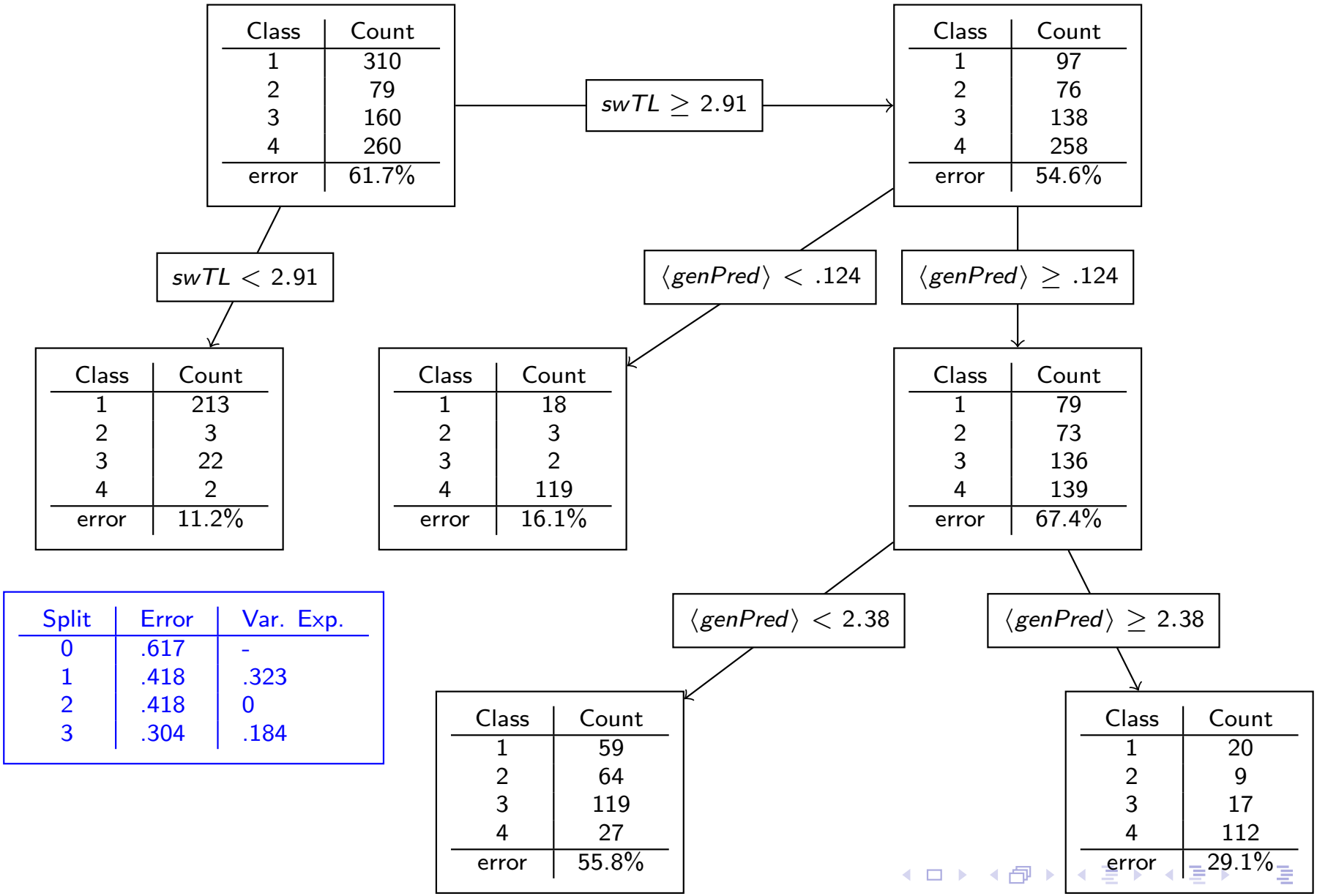

Split	Error	Var. Exp.
0	.617	-
1	.418	.323
2	.418	0
3	.304	.184

Classification Tree + Niche Model

- Generate Niche Model

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- Parasites from Classification Tree or Randomly

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- To do:

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  - Classification on ONM/INM
  - Consumer-Resource body size ratios

Numerical Experiments

- Constant body mass ratios already studied

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Numerical Experiments

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- Where do empirical webs fit in the pattern?

Numerical Experiments

- Constant body mass ratios already studied
- What is maximum fraction of parasites allowed?
- Where do empirical webs fit in the pattern?
- How do concomittant links affect that pattern?

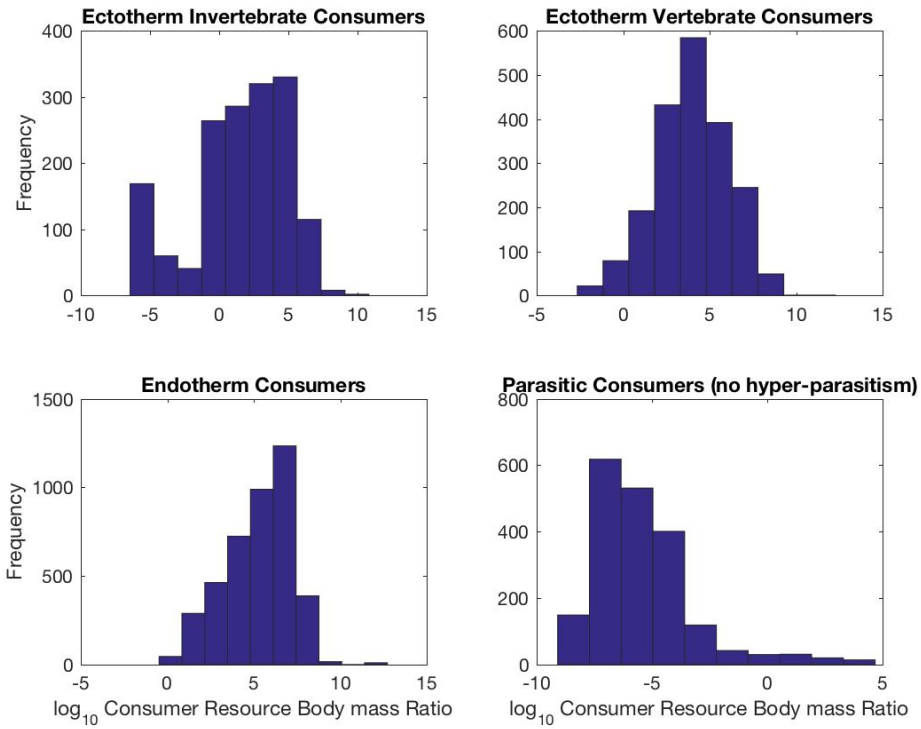
Dynamical Model

$$\begin{aligned}\frac{dB_i}{dt} &= r_i\left(1-\frac{\sum_{j\in\text{basal}} B_j}{K}\right)B_i \\ &-x_i B_i \\ &+\phi_i x_i B_i \sum_{j\in\text{diet}(i)} F_{ji} y \\ &-\phi_i \sum_{j\in\text{pred}(i)} x_j B_j F_{ij} y / e_{ij} \\ &-(1-\phi_i)\{\text{Concomittant Losses}\}\end{aligned} \tag{1}$$

and

$$F_{ij} = \frac{\omega_{ij} B_i^h}{B_0^h + \sum_{k\in\text{diet}(j)} \omega_{kj} B_k^h} \tag{2}$$

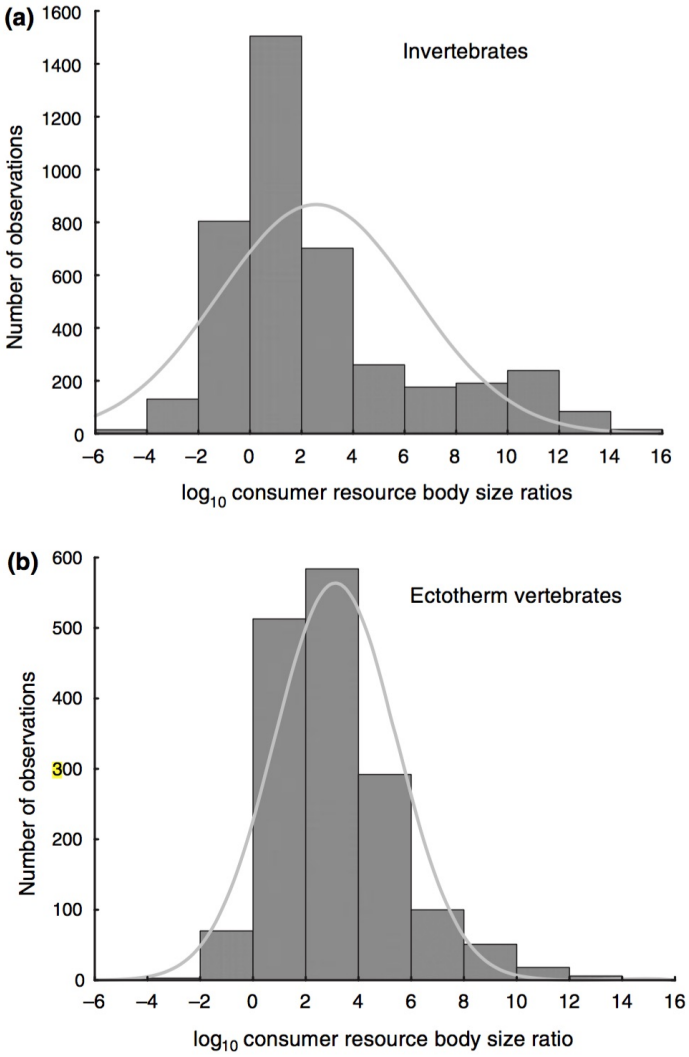
Body Mass Ratios[4]



Type	Median
Ecto. Inv.	72.1 (318)
Ecto. Vert.	887
Endo.	2160
Para.	1.77×10^{-6}

[4] U. Brose, R. J. Williams, and N. D. Martinez, *Allometric scaling enhances stability in complex food webs*, Ecology Letters, 9 (2006), pp. 1228–1236

Body Mass Ratios[4]



Type	Median
Ecto. Inv.	14
Ecto. Vert.	398

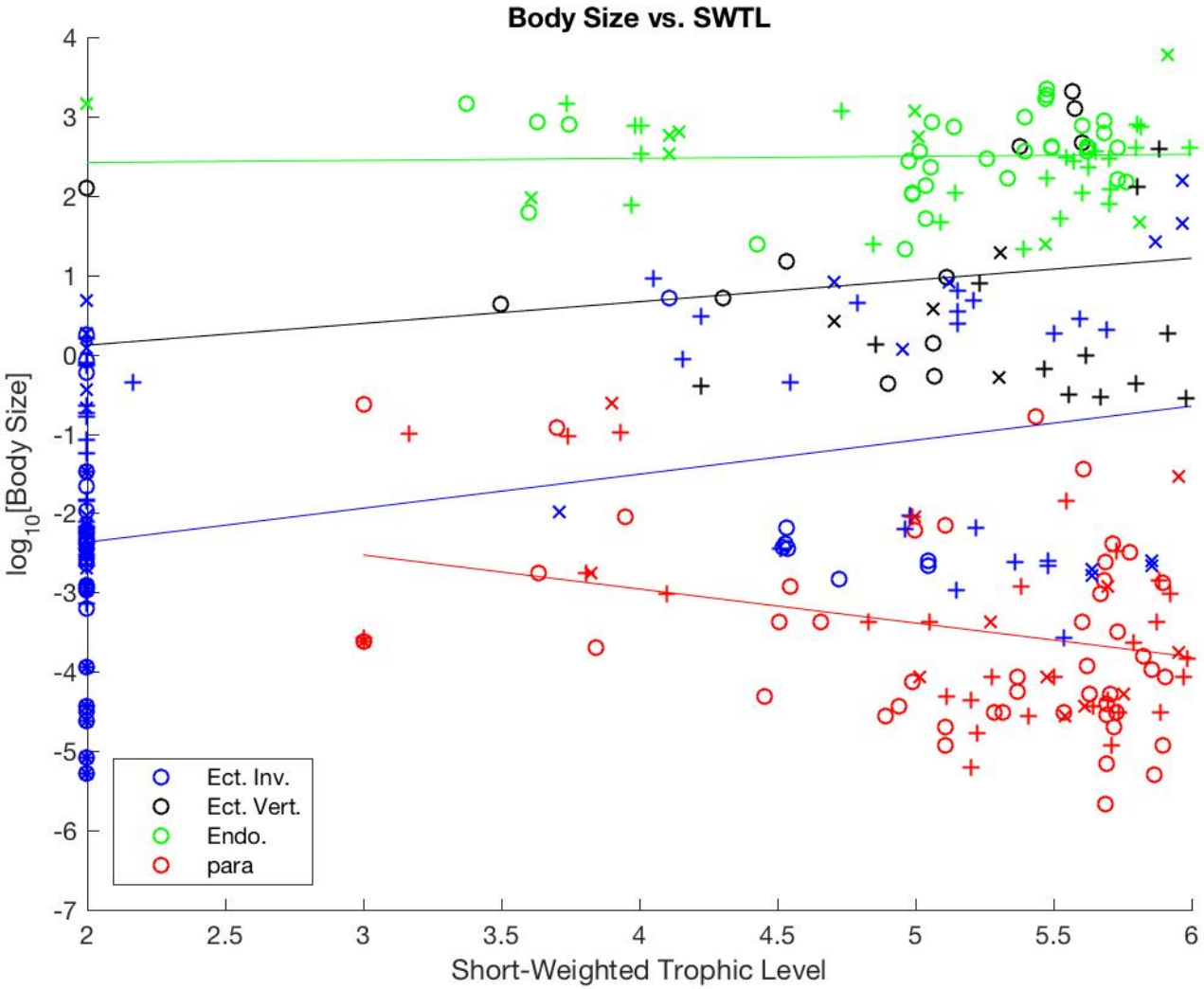
[4] U. Brose, R. J. Williams, and N. D. Martinez, *Allometric scaling enhances stability in complex food webs*, Ecology Letters, 9 (2006), pp. 1228–1236

Body Mass Ratios[4]

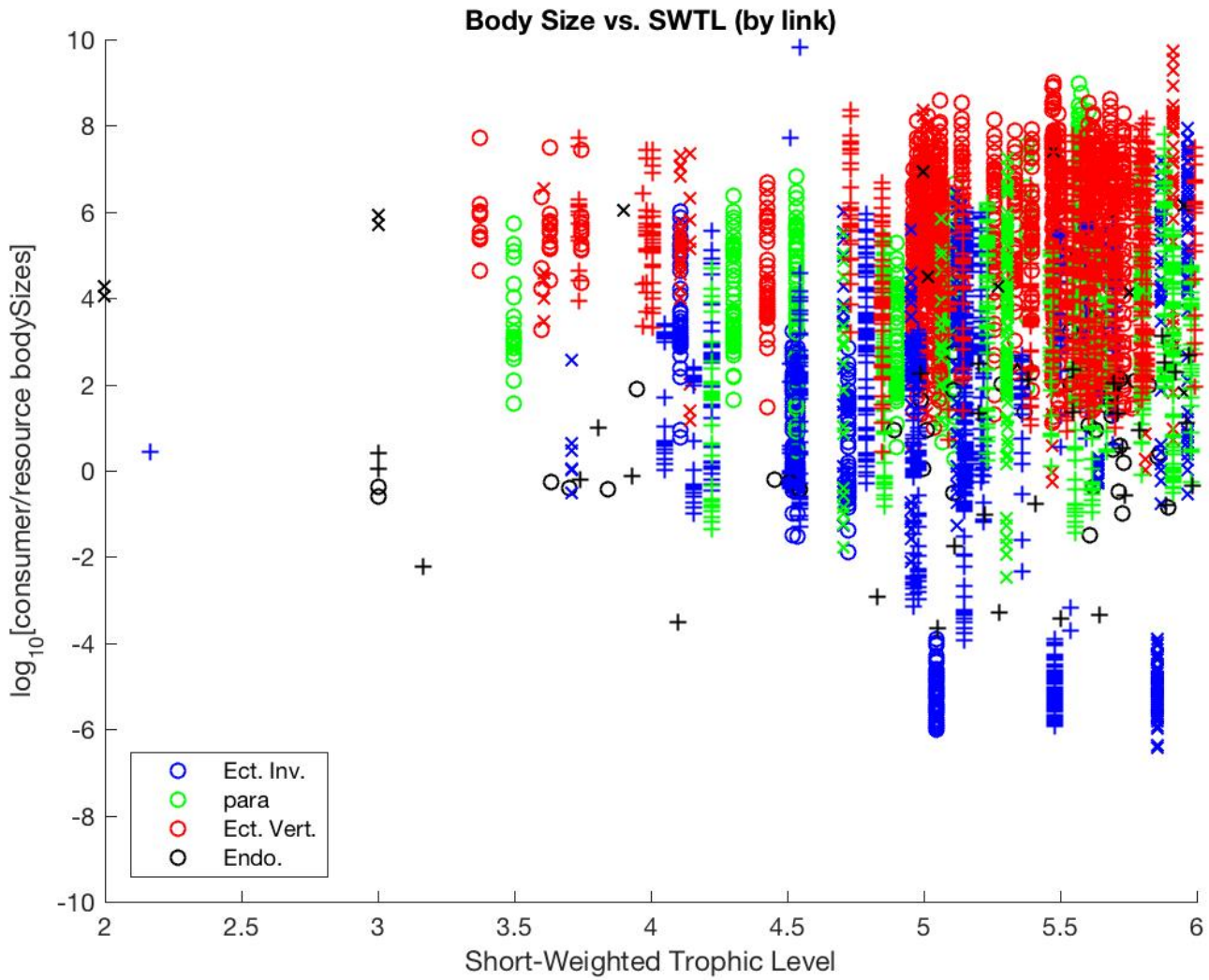
- Parasites are small.
- To parameterize: $M = Z^{TL}$.

[4] U. Brose, R. J. Williams, and N. D. Martinez, *Allometric scaling enhances stability in complex food webs*, Ecology Letters, 9 (2006), pp. 1228–1236

Body Size Ratios & Body Sizes



Body Size Ratios & Body Sizes



Dynamical Model: Next Steps

- Allometric scaling for parasites

Dynamical Model: Next Steps

- Allometric scaling for parasites
- Concomittant Losses