Temporal Development and Collapse of an Arctic Plant-Pollinator Network

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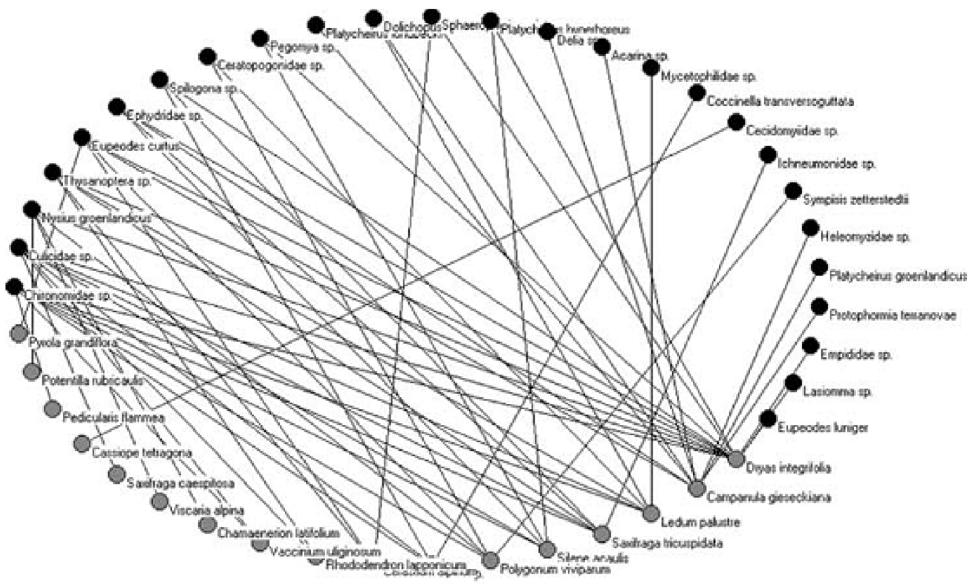
Learning in Computational Systems Biology

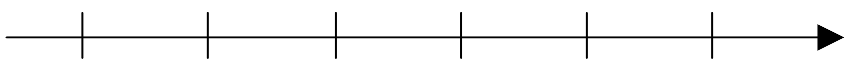
Overview

- Plant-Pollinator Networks
- Modeling
- Results
- Conclusion/ End

Plant-Pollinator Networks

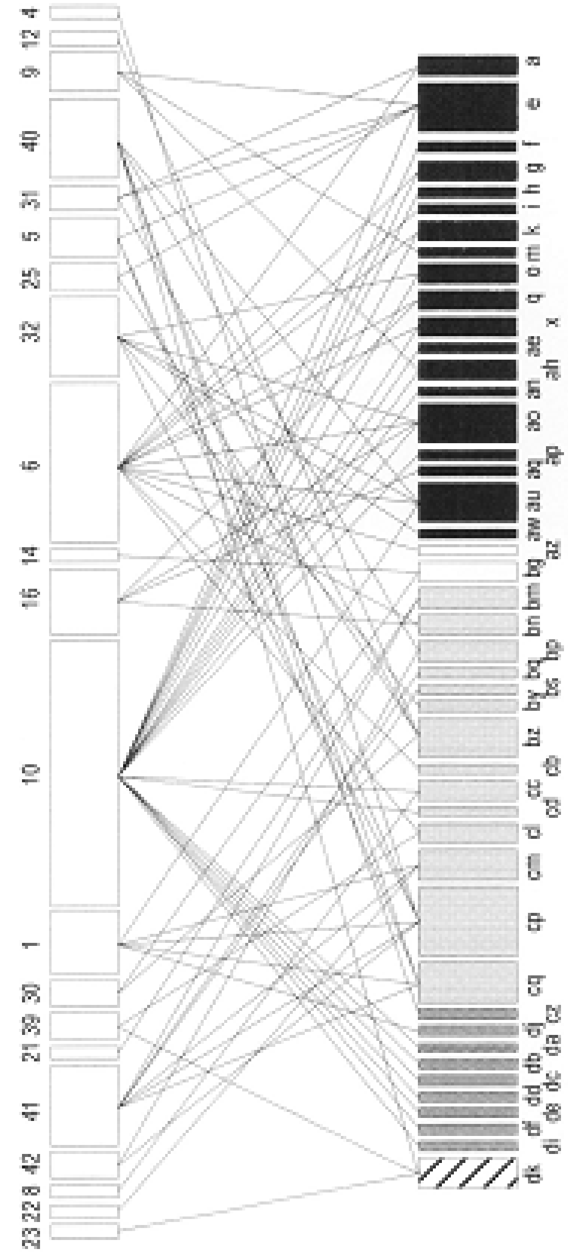


Lundgren & Olesen, 2005



Prefixed Time Points

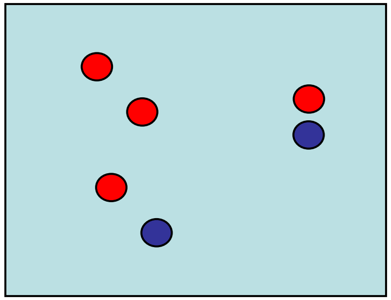
Habitat Change
Climate Change

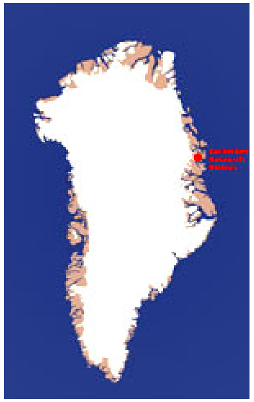


Medan et al, 2002

Arctic Plant-Pollinator Network Zackenberg 1996-97

Olesen et al, 2008

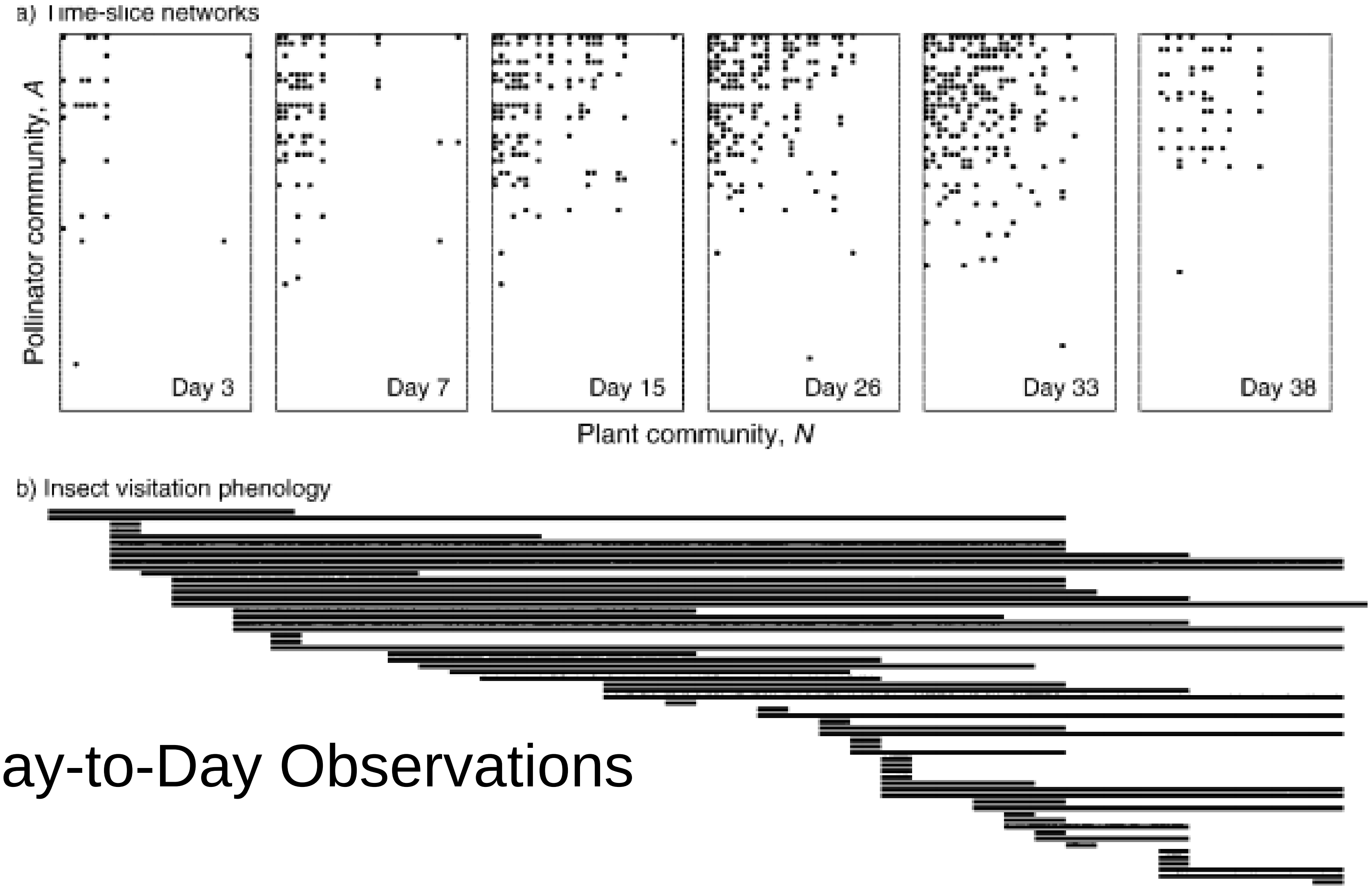




Network parameter	First year	Second year	Both years
Start of season	21 June	17 June	
End of season	2 August	24 August	
Length of season (days)	43	69	
A, no. pollinator species	61	64	76
N, no. flowering plant species	31	31	31
$M = A \times N$, network size	1891	1984	2356
I, total no. links in network	286	268	452
$C = I/M$, network connectance	0.15	0.14	0.19
$\langle L_i \rangle = I/A$, mean linkage level of pollinators	4.7	4.2	5.9
$\langle L_j \rangle = I/N$, mean linkage level of plants	9.2	8.6	14.6

Arctic Plant-Pollinator Network

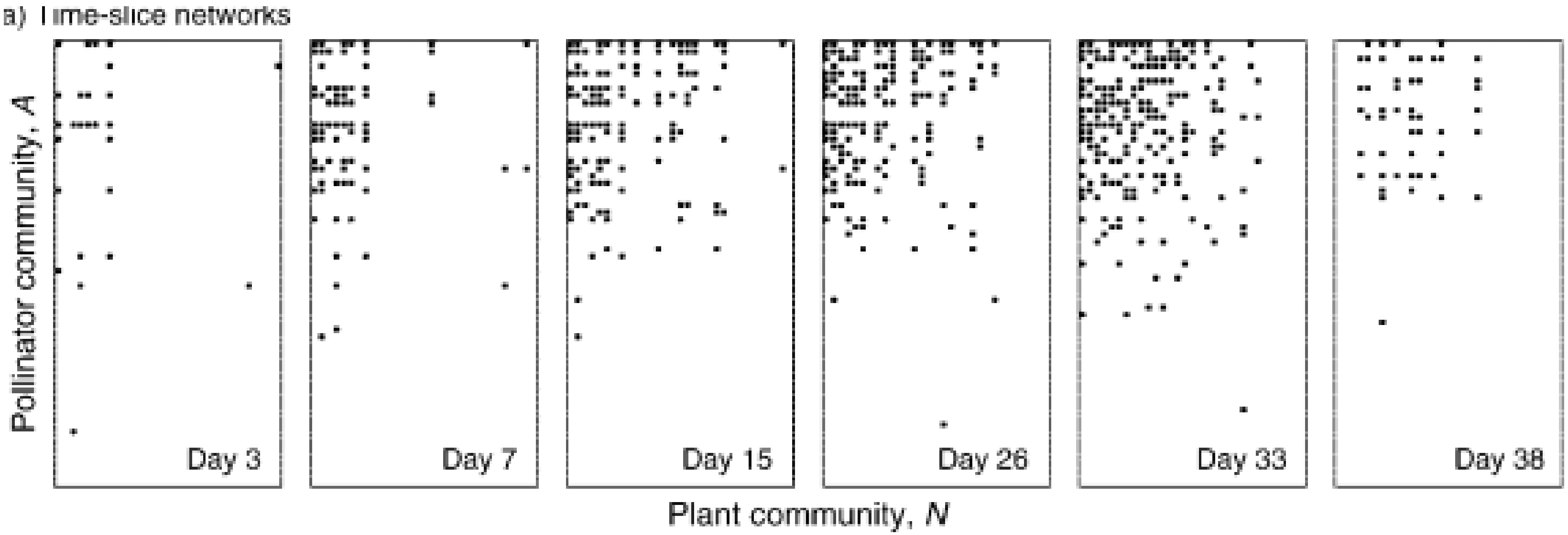
Olesen et al, 2008



Day-to-Day Observations

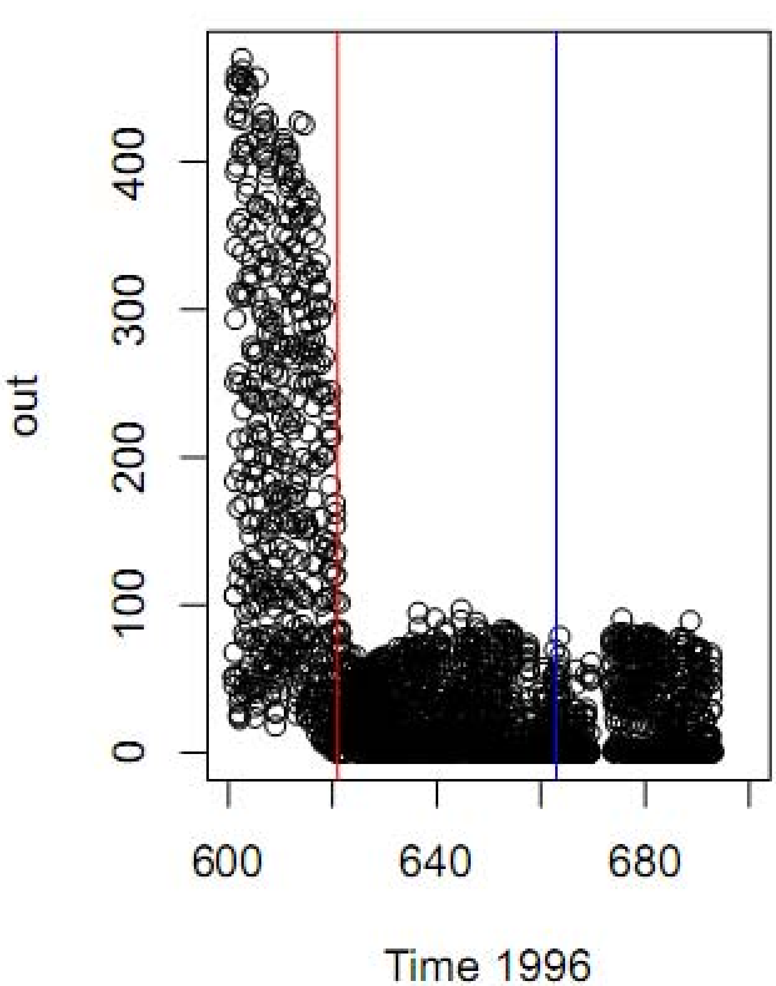
Arctic Plant-Pollinator Network

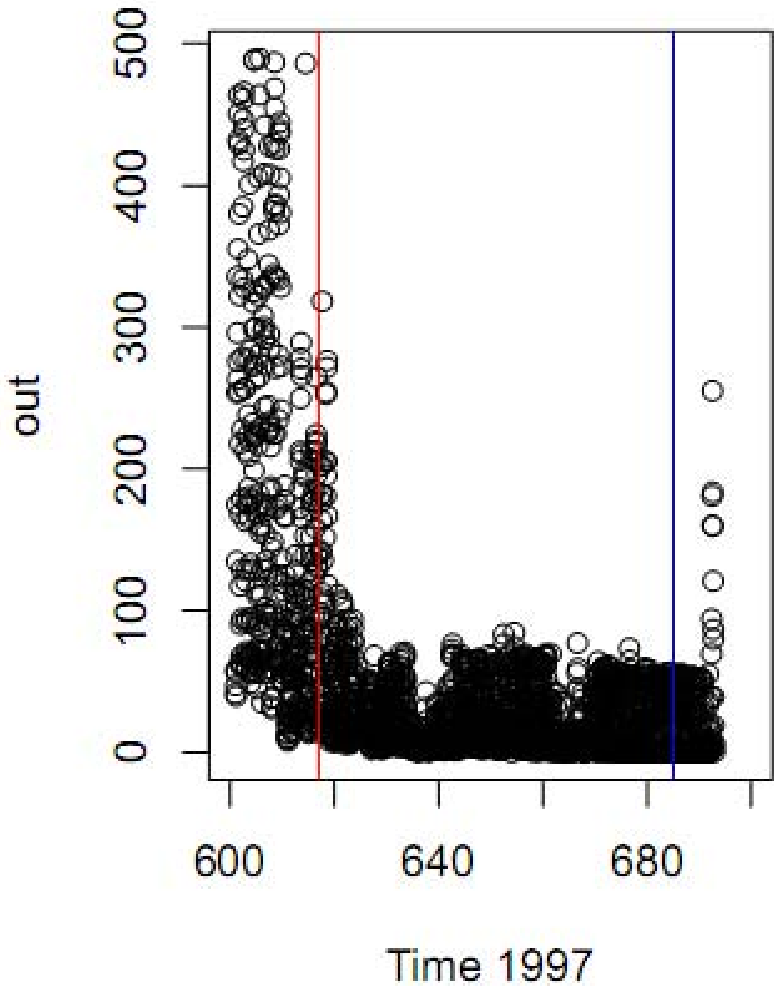
Olesen et al, 2008



Provide simple description of how the network is build up
Does the weather influence the dynamics?

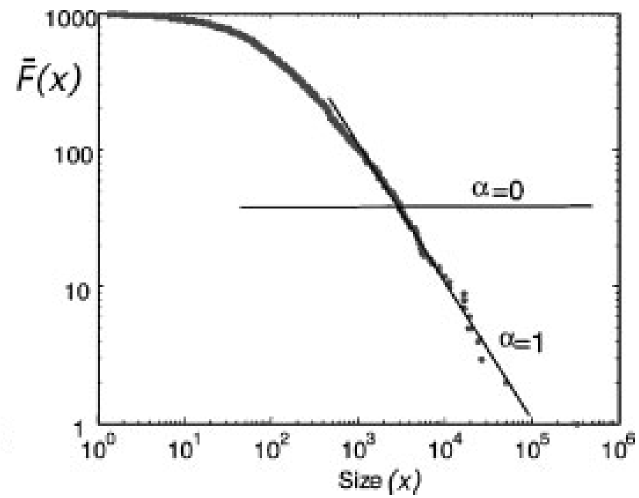
Start of Season at Zackenberg





Network Modeling

- Random Network
- Scale-free/ Power Law
- Preferential Attachment
- Small World

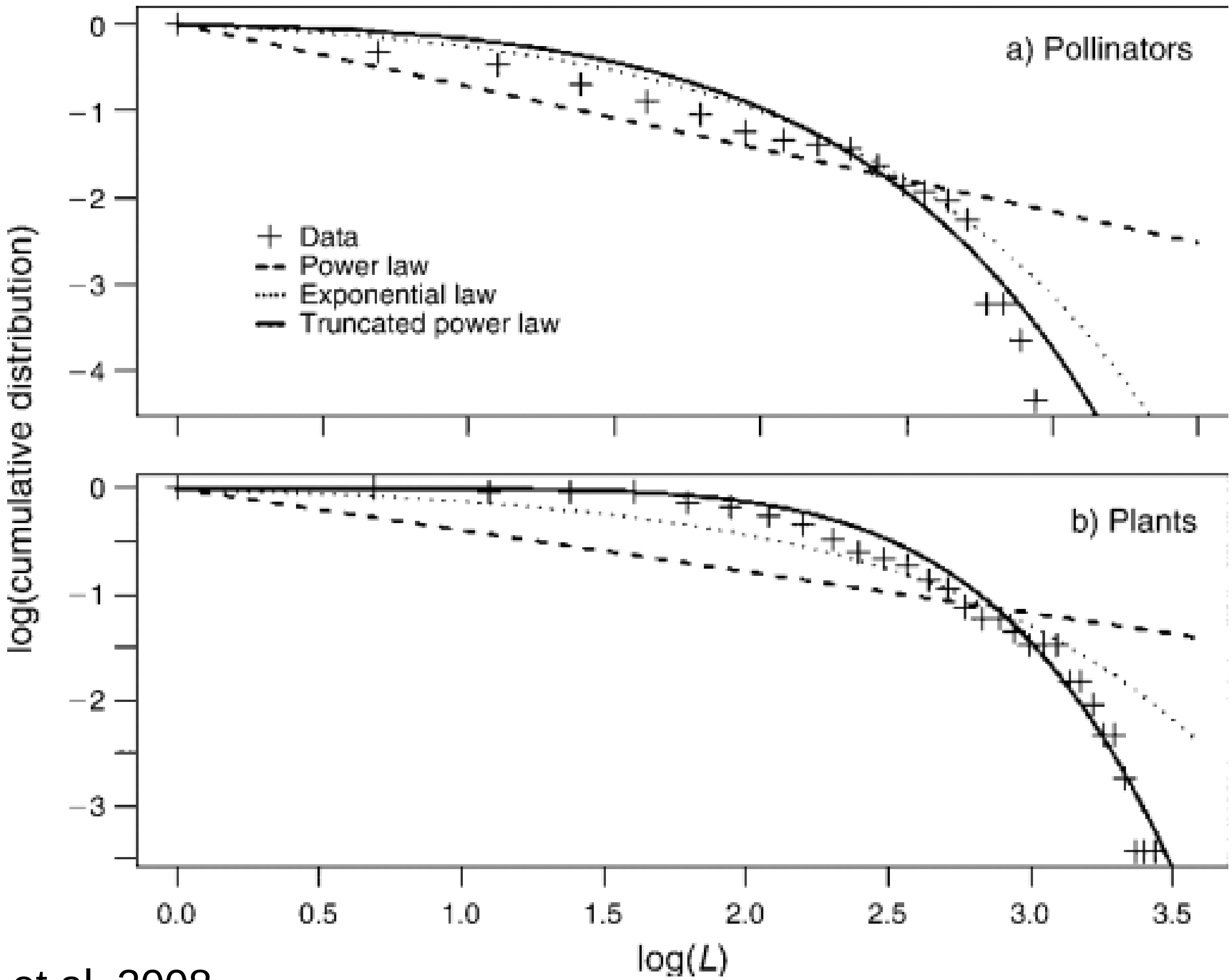


Revisiting "scale-free" networks

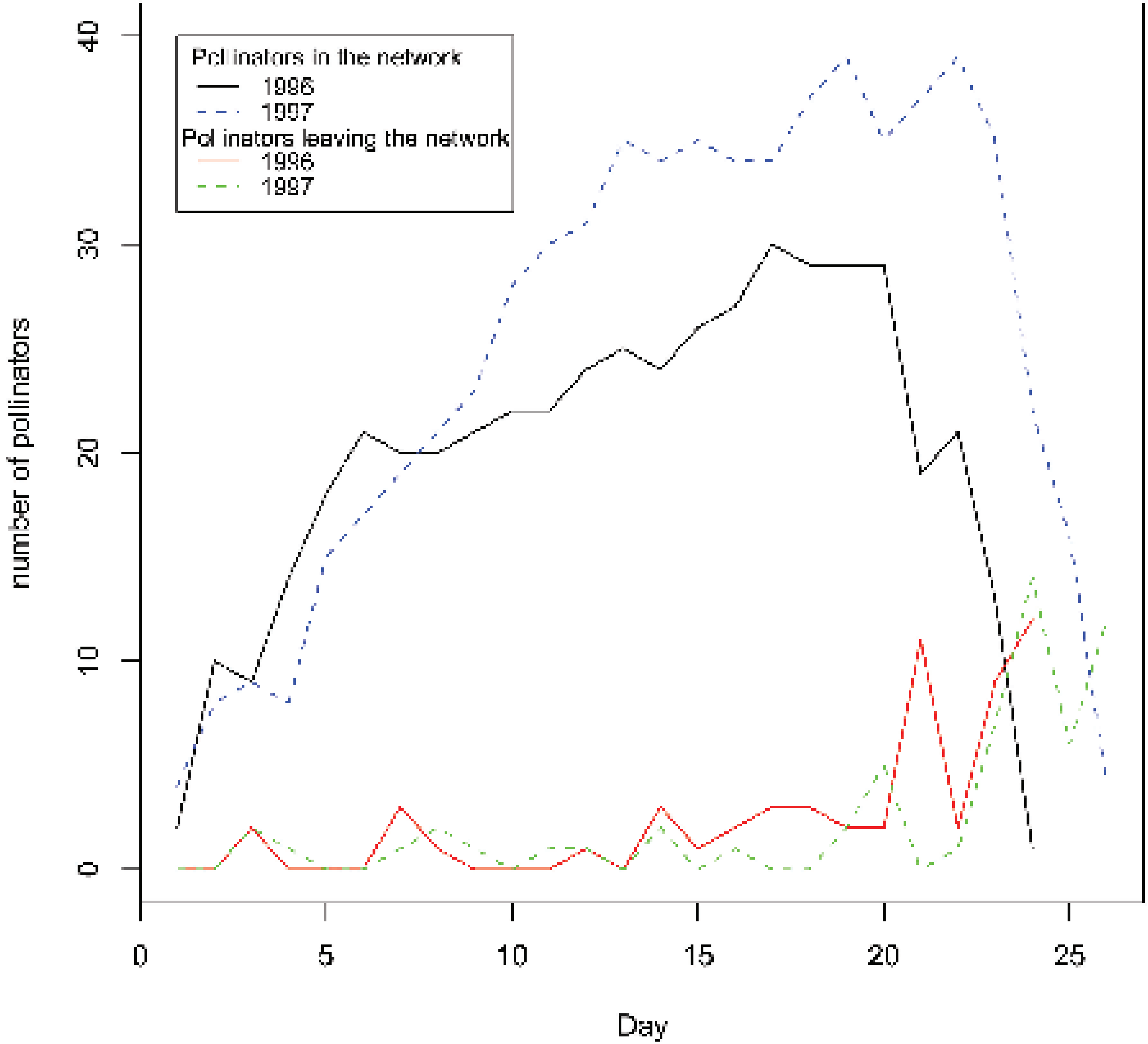
Evelyn Fox Keller*

BioEssays 27.10

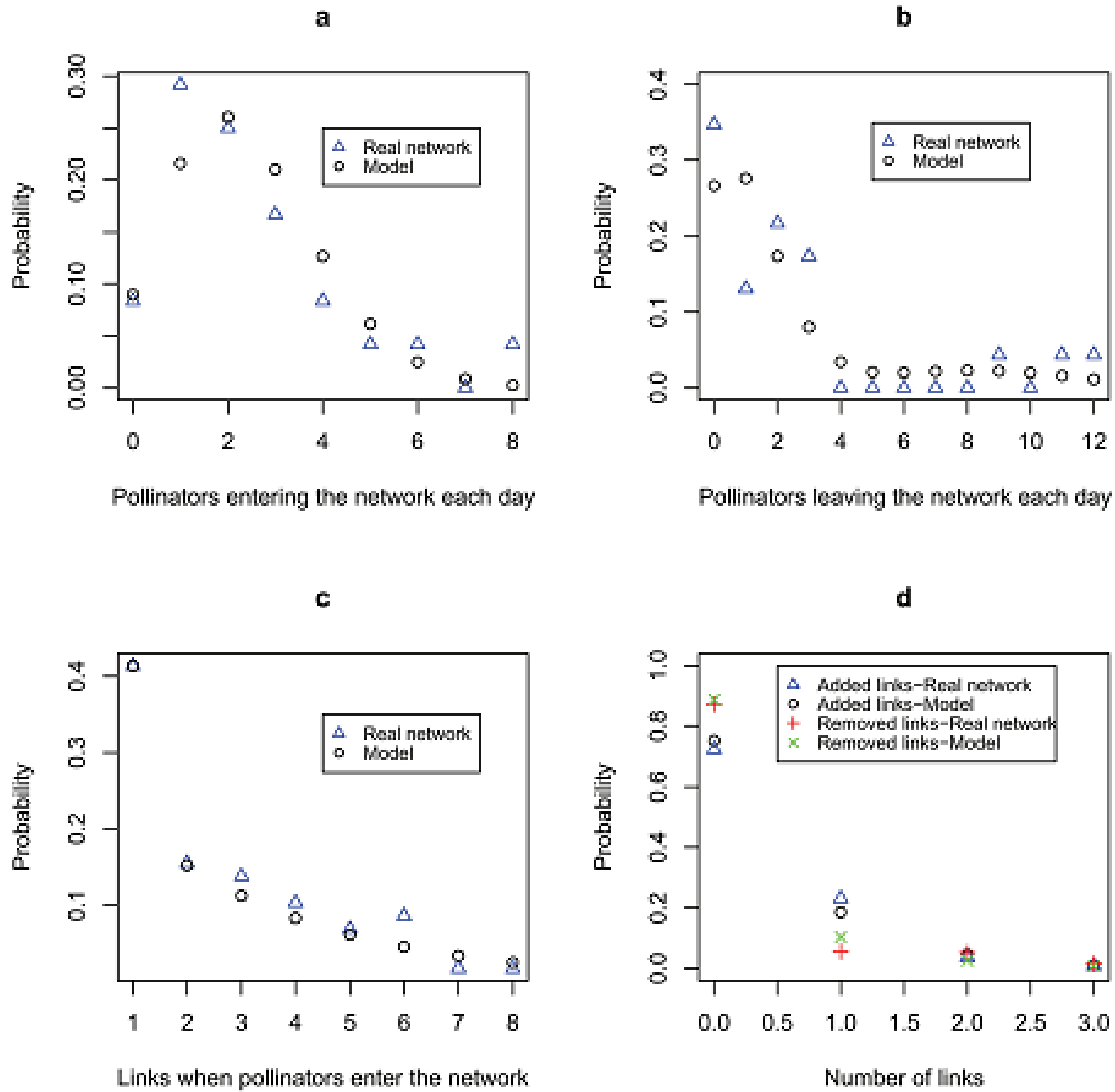
Network Modeling



Olesen et al, 2008



Zackenberg 1996-97

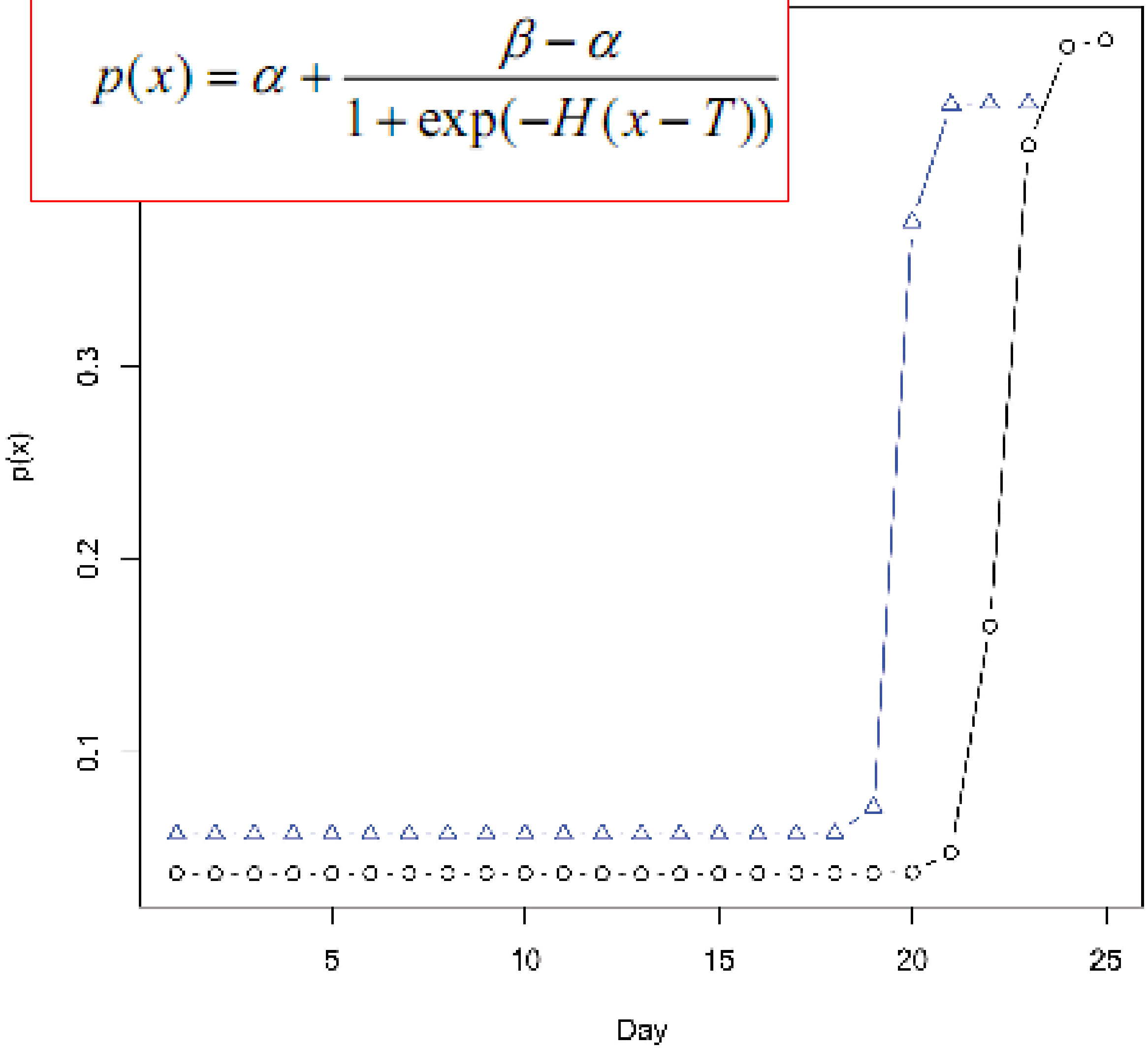

a
Real network
Model
Probability
Pollinators entering the network each day
b
Real network
Model
Probability
Pollinators leaving the network each day
c
Real network
Model
Probability
Links when pollinators enter the network
d
Added links–Real network
Added links–Model
Removed links–Real network
Removed links–Model
Probability
Number of links

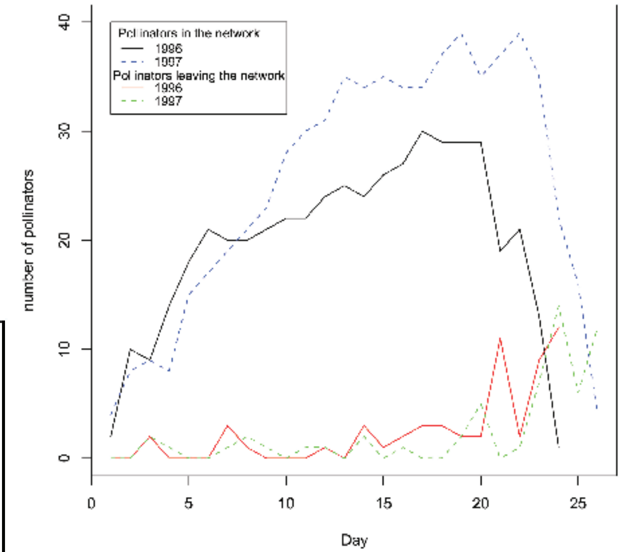
Parameter Estimates

	Distribution	1996	1997	1996 and 1997	LTR
Arrival of insects	Poisson	$\lambda = 2.417\ (0.317)$ $p = 0.094$	$\lambda = 2.423\ (0.305)$ $p = 0.15$	$\lambda = 2.420\ (0.220)$ $p = 0.28$	Yes $p = 0.99$
Links for new insects	Modified geometric	$r_1 = 0.414\ (0.065)$ $r = 0.351\ (0.049)$ $p = 0.65$	$r_1 = 0.429\ (0.062)$ $r = 0.356\ (0.048)$ $p = 0.37$	$r_1 = 0.421\ (0.045)$ $r = 0.354\ (0.034)$ $p = 0.55$	Yes $p = 0.98$

“Death” of Insects

$$p(x) = \alpha + \frac{\beta - \alpha}{1 + \exp(-H(x - T))}$$





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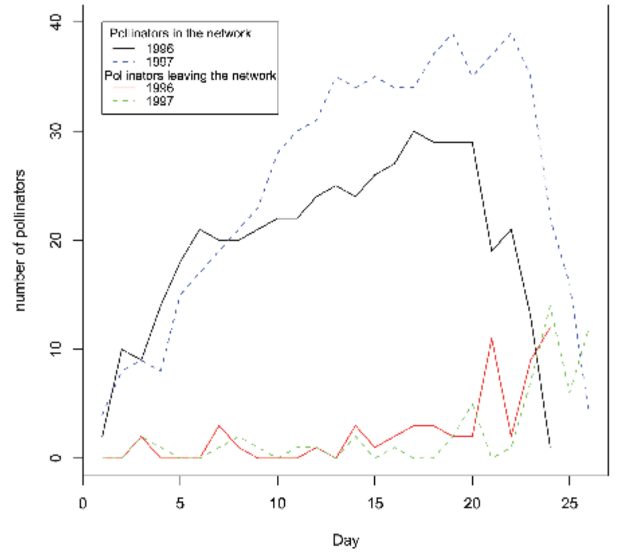
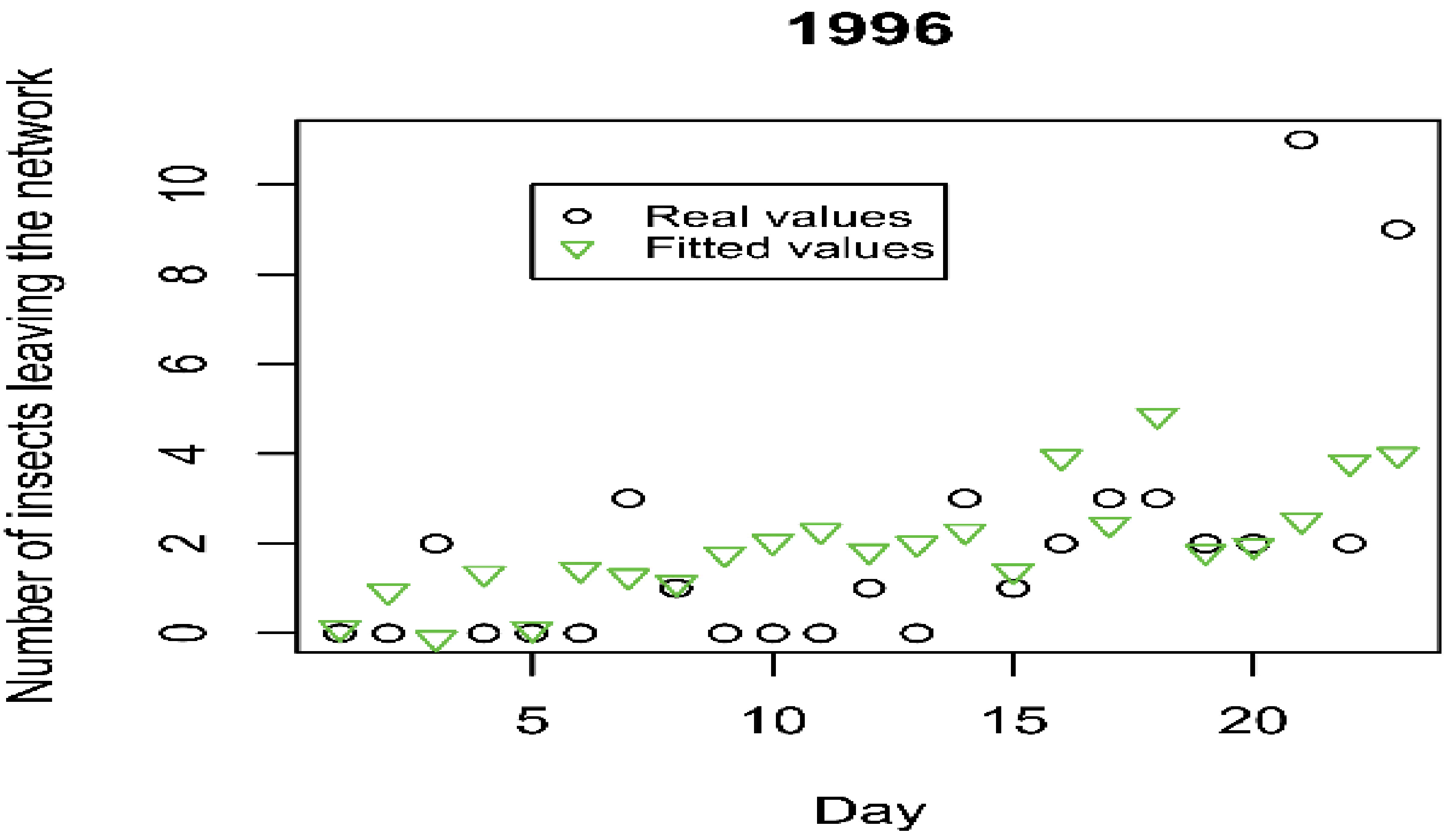


Death of insects	Modified binomial	$\alpha = 0.058\ (0.012)$	$\alpha = 0.037\ (0.008)$	$\alpha = 0.046\ (0.007)$	Yes
		$\beta = 0.436\ (0.071)$	$\beta = 0.469\ (0.143)$	$\beta = 0.446\ (0.063)$	$p = 0.57$
		$H = 4.901\ (4.942)$	$H = 2.797\ (3.688)$	$H = 3.847\ (3.984)$	
		$T = 19.66\ (0.362)$	$T = 22.31\ (0.747)$	$p = 0.75$	
		$p = 0.41$	$p = 0.51$		

Can the weather explain it?



Model for Network Growth

	1996	1997
Maximum number of links	163 (29.5) 200 (0.210)	164 (35.8) 190 (0.717)
Total number of insects	57.7 (6.80) 61 (0.628)	64.6 (9.36) 64 (0.951)
Total number of interactions	277 (36.0) 286 (0.792)	266 (48.4) 268 (0.963)
Maximum number of insects	30.8 (5.29) 30 (0.874)	34.0 (6.00) 39 (0.408)
Connectance	0.155 (0.012) 0.15 (0.694)	0.133 (0.014) 0.14 (0.581)
Pollinator average linkage level	4.80 (0.381) 4.7 (0.793)	4.11 (0.421) 4.2 (0.827)

Conclusions

- Similar dynamics in both years
- The model supports that the network is build up randomly; not preferentially
- Severe collapse of the network a few days before end of season
- Weather does not correlate with dynamics
- Network does not reach equilibrium

Acknowledgement

- Joint work with
  - Clementine Predal, Ecole Centrale Paris
  - Jens Mogens Olesen, Aarhus University

END